S. HRG. 99-296

DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS—FISCAL YEAR 1986

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON
ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

NINETY-NINTH CONGRESS

FIRST SESSION

ON THE

DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS

APRIL 17, 30, MAY 9, 13, AND 14, 1985

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DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS—FISCAL YEAR 1986

(Environment, Safety, and Health)

WEDNESDAY, APRIL 17, 1985

U.S. Senate,
Subcommittee on Energy Research and Development,
Committee on Energy and Natural Resources,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:13 p.m., in room SD-366, Dirksen Office Building, Hon. Pete V. Domenici presiding.

Present: Senators Domenici, Warner, Evans, and Ford.

Also present: Paul Gilman, professional staff member; Benjamin S. Cooper, professional staff member for the minority; and James T. Bruce, counsel for the minority.

OPENING STATEMENT OF HON. PETE V. DOMENICI, A U.S. SENATOR FROM THE STATE OF NEW MEXICO

Senator Domenici. I would like to call the meeting to order. We are on a short timeframe, so I have a very brief opening statement and then I will yield to Senator Ford.

Today we have Assistant Secretary William Vaughan, who is Acting Assistant Secretary for Policy, Safety and Environment at DOE, here to testify on the Department's budget request for environment, safety and health. These are the programs through which the DOE regulates its activities to assure that they are done in a safe and environmentally acceptable manner. Their record in this area has been generally good. There is room for improvement, and I am sure that the Secretary would acknowledge that.

In this regard, I urged Secretary Herrington, at his nomination hearing in January, to consider creating an Assistant Secretariat with this responsibility and this responsibility alone. I will be interested to hear from Mr. Vaughan if anything is happening in this regard.

Now, as soon as I have yielded to the distinguished Senator from Kentucky, we will ask the Secretary to testify.

Senator Ford.

Senator Ford. I thank the chairman. I have no statement to make. I do have some questions of the Acting Secretary, and I look forward to his testimony.

Senator Domenici. Thank you very much, Senator Ford.

We have your prepared remarks, Mr. Vaughan. They will be made a part of the record. You may proceed to summarize them or give them as you see fit; however, if you give it too much detail, we are not going to have time for anything else.

STATEMENT OF HON. WILLIAM A. VAUGHAN, ACTING ASSISTANT SECRETARY, POLICY, SAFETY, AND ENVIRONMENT, DEPARTMENT OF ENERGY; ACCOMPANIED BY ROBERT STERN, ACTING DEPUTY ASSISTANT SECRETARY, ENVIRONMENT, SAFETY AND HEALTH

Mr. VAUGHAN. Mr Chairman, I'll try to very briefly summarize the highlights.

Senator DOMENICI. It would be appreciated.

Mr. VAUGHAN. I would like to introduce Mr. Robert Stern, who is the Acting Deputy Assistant Secretary for Environment, Safety, and Health. He is on your right, my left.

As we look at the Environment, Safety and Health Program for the Department of Energy, I think it is important to note, as you said in your opening statement, sir, that the Department has an exemplary record, particularly in the nuclear safety and occupational safety areas.

In the environment area, it has a very good record, but it does have some room for improvement. Rather than go into the details of our jurisdiction which are a matter of record, I think it would be appropriate to turn rather quickly to a very brief statement as to how we operate and what our programmatic goals are in environment, safety and health during the upcoming fiscal year.

In the Office of Environment, Safety and Health in the Department headquarters, the role is to provide an independent overview and assessment for the Secretary, so that he can assure that these facilities scattered across the country are being operated in accord with applicable Federal and State standards, laws, and regulations.

As you know, traditionally, the Department has had its own enforcement of these standards and regulations because of the historical linkage to the Atomic Energy Commission, and it is from that lineage that this independence has had its origin.

The office which I currently head provides an independent oversight to programs out in the field and the program Assistant Secretaries are responsible as line managers for compliance. And then our job is to set standards and then check to see that the standards are in fact adhered to.

That is what we mean by independent oversight. I think by any comparison to industrial performance, the Department's record is exemplary. I think in comparison to nuclear facilities that are regulated by the NRC, again the Department's record is exemplary. And I think that it has a very good record in environmental areas, but these are areas that I indicated could use some improvement.

Secretary Herrington, upon arriving, has indicated a great interest in this field of activity, and I think I can assure this committee that he takes these reponsibilities quite seriously.

Last, I would like to quickly run down the list of activities we contemplate for the fiscal year. And I am going to talk essentially about the 1986 objectives. We believe that we need to develop better training guidance for reactor and nuclear facility operators, to improve operational safety at our nuclear facilities.

After all, our facilities are some of the original nuclear facilities the country possessed. Many of them are unique, and some of them are fairly old. So we need to continue to improve, even though the record of accomplishment in safety is exemplary.

We need to develop improved methods of internal radiation dose assessment to assure compliance with radiation exposure limits established by both national and international authorities.

We are issuing currently revised environmental protection safety and health protection guidance to the Department and we are conducting appraisals of performance in these areas of the headquarters program organizations and ensuring that they in turn are evaluating their own field operations on at least a biennial basis.

We are providing assistance to the Department's programs and projects to ensure compliance with the National Environmental Policy Act. And I believe that in this area of activity, the Department has an outstanding section that provides consistent compliance with not only the letter, but the spirit of this particular law.

Finally, it is our job to participate in environmental protection and regulatory working groups to ensure that the impacts of proposed environmental regulations and laws on energy policies as well as the energy industry and our own facilities are fully understood and considered inside the administration.

I think, Mr. Chairman, that that terminates my brief overview and summary of the more formal statement, and I am ready for the committee's questions.

[The prepared statement of Mr. Vaughan follows:]

OPENING STATEMENT

BY WILLIAM A. VAUGHAN

ACTING ASSISTANT SECRETARY FOR POLICY, SAFETY, AND ENVIRONMENT

Mr. Chairman and Members of the Subcommittee, I am pleased to be here today to discuss with you the Department's budget request for FY 1986 for the Office of Environment, Safety and Health. With me to assist in responding to your questions is Robert J. Stern, the Acting Deputy Assistant Secretary for Environment, Safety and Health.

NATIONAL ENERGY POLICY PLAN AND SAFE, ENVIRONMENTALLY SOUND OPERATION OF DOE ACTIVITIES

The overall goal of our national energy policy is to foster an adequate supply of energy at reasonable costs. The two strategies to achieve this goal are (1) to promote a balanced and mixed energy resource system and (2) to minimize federal control and involvement in energy markets while maintaining public health and safety and environmental quality. In addition, the Department is responsible for the manufacturing of nuclear weapons for national defense purposes. The DOE Organization Act establishes the Departmental goal of protecting and enhancing environmental quality and assuring public health and safety. The Department's goal is for all of its activities to be operated in a safe, healthy and environmentally sound manner.

The Department's health and safety record has been outstanding by any standard. Its environmental record has also been good. However, the increasingly complex and dynamic situation regarding environmental regulations is requiring DOE to reevaluate previously accepted practices and place a higher priority on environmental issues.

The Headquarters Environment, Safety, and Health (ES&H) functions are to establish Departmental policy, provide guidance and technical assistance, perform safety related research of a generic nature, and perform an independent overview and assessment role for the Secretary. The line organizations starting with the DOE contractor, continuing through the DOE operations office and the program office, have responsibility and accountability for the safe, healthy and environmentally sound performance of their activities.

GOAL OF OFFICE OF ENVIRONMENT, SAFETY AND HEALTH

The goal of the Office of Environment, Safety and Health is to assure safe and environmentally sound operation of DOE activities. This is done by providing the Secretary and the Department a competent, adequate, independent oversight capability at headquarters which (i) as appropriate reviews, assesses, appraises and in some cases approves, Departmental (including contractor) activities; (ii) develops appropriate policies, standards and guidance for DOE; (iii) identifies and supports research to assist DOE to operate in a safe and environmentally sound manner; and (iv) provides related technical (including quality assurance) assistance to Departmental activities to assist them in operating in this manner. These functions are performed while recognizing the unalterable responsibility of the line organizations for safe and environmentally sound operation of the activities under their supervision.

Achieving the Department's environmental, safety and health protection and quality assurance objectives hinges on a solid partnership between the Environment, Safety, and Health Office and the Department's line programs. The ES&H Office furnishes the line programs with applicable ES&H requirements through general policy orders, monitors their efforts in complying with these requirements, and assists with technical advice in resolving implementation problems. This allows the line organizations, which have the principal responsibility for safe and environmentally sound operations, to proceed with greater assurance that they will not incur interruptions from accidents or litigation stemming from non-compliance with ES&H-related laws or policies.

OUTSTANDING SAFETY AND HEALTH RECORD

The Department's safety and health record in 1984 was excellent. The Department has the safety and health responsibility for 165,000 Federal and contractor employees (309 million hours worked) who operate facilities with a property replacement value of greater than $30 billion. The Department's fatality, injury, and illness rates for FY 1984 were well below the rates of the private sector.

During FY 1984 there were seven work-related fatalities. The FY 1984 fatality, injury, and illness rates for DOE Federal and contractor operations continue to be approximately two-to-three times better than comparable rates of the private sector. None of the FY 1984 injuries or illnesses were caused by radiation exposure, and there were no accidental exposures in excess of the various allowable annual limits.

The total reported property loss for the Department in FY 1984 was approximately $8.9 million. The loss rate was approximately one cent for every hundred dollars of property valuation.

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The operations of the Department's 18,000 motor vehicles resulted in 500 accidents during 19 million miles of travel in FY 1984. The accidents per million miles and dollar loss per 1,000 vehicle miles rates were less than one-half the comparable rates for all nation-wide travel, as reported by the National Safety Council. In addition, there were no marine or railroad losses reported during FY 1984, and no accidents involving the operation of Department-owned or -leased aircraft.

PRINCIPAL STATUTORY AUTHORITY

The statutory authority governing the ES&H Program includes the DOE Organization Act which establishes a Departmental goal of protecting and enhancing environmental quality and assuring public health and safety; the Atomic Energy Act which exempts DOE and its contractors from certain licensing requirements (The DOE requires that the Department's operations be conducted in accordance with comparable health and safety practices as required by EPA regulations, Occupational Safety and Health Act, Federal Regulations for Federal Employees.); and the National Environmental Policy Act. This Act requires consideration of environmental factors in agency decisionmaking, including as appropriate, the preparation of environmental assessments and environmental impact statements.

PROGRAM ORGANIZATION

Functions of the Headquarter's ES&H organization are carried out by five major components: Nuclear Safety, Quality Assurance and Standards, Operational Safety, Environmental Compliance, and Environmental Analysis. Their activities include the development of policies and standards; oversight to monitor program and field office performance in complying with

DOE policies and standards, technical and policy guidance assistance to foster compliance; the review of National Environmental Policy Act documents; and the analysis of energy/environmental issues.

FUNDING

For FY 1986 we are re ing $39.6 million for the Environment, Safety and Health Program which is $1.5 million more than appropriated in FY 1985 as noted in the following table, and discussed in the following sections. The increase is principally in funding the salaries and benefits of the federal staff. The staff increases by only one person above FY 1985, however, appropriated funding in FY 85 is insufficient to cover program direction by $1.1 million which is being provided from prior years uncosted unobligations which are available for use in FY 1985 for this urgent priority. The programmatic activities will continue in FY 1986 at essentially the same level of effort as in FY 1985.

FUNDING SUMMARY

(Budget Authority in Millions)

Environment Safety and Health	FY 1985 Appropriation	FY 1986 Request
Operating Expense:		
Nuclear Safety	$ 17.4	$ 17.6
Quality Assurance and Standards	1.0	1.0
Operational Safety	9.1	9.1
Environmental Compliance	1.7	1.7
Environmental Analysis	2.5	2.6
Program Direction	4.9 a/	6.1
Subtotal	36.6	38.1
Capital Equipment	1.5	1.5
Total ES&H	$ 38.1	$ 39.6
Staffing - Full-time equivalent	100 b/	101 b/

a/ Total estimated funding to support the planned 100 FTE's in FY 85 is $6,100,000.

b/ Excludes 3 FTE's budgeted under the Nuclear Waste Act Fund.

FY 1985 PROGRAM PLANS

The FY 1985 plans include:

- Conducting environmental protection, nuclear safety, and health protection appraisals of several field organizations. The appraisals include related functional areas which may be performed simultaneously, and can serve as a basis for assessing the overall management of ES&H by the field office.

- Testing the DOE capability to respond to radiological emergencies in two major demonstrations.

- Continuing the coverage provided by the Atmospheric Release Advisory Capability, an emergency response system for predicting effects of radiological releases.

- Establishing criteria and procedures for intercomparison of radiological calibration services and instruments among DOE facilities and its contractors.

- Completing a job and task analysis and a training program for chemical process operations based on instructional system development methodology.

- Completing the development of an improved nuclear criticality alarm system.

- Conducting independent reviews of several safety analysis reports for high hazard nuclear operations prepared by program organizations.
- Completing approximately 15 quality assurance appraisals of DOE contractor facilities/projects/operations.
- Beginning operations of the Safety Performance Measurement System modules for environmental data reporting and tracking of appraisal recommendations.
- Continuing fire protection surveys with first priorities being those sites that have not been resurveyed for the longest period. Candidate sites planned are: Richland, Sandia, Los Alamos, Nevada Test Site, and Mound Laboratory.
- Initiating an effluent monitoring program which will evaluate monitoring system designs, procedures and performance at DOE facilities, for both routine and accidental releases. Planned accomplishments include development of checklists, establishment of visit priorities, and the analysis and independent verification of samples.
- Providing environmental compliance support, assurance, and oversight to DOE programs, projects, and other initiatives subject to the National Environmental Policy Act (NEPA) and other related environmental requirements; including 180 analyses to determine/confirm the level of NEPA documentation requirements for DOE actions; and 125 major

independent reviews of NEPA Environmental Impact Statements (EIS's) and Environmental Assessments (EA's). Examples of major EIS reviews include those for: High-Level and Transuranic Waste Management Activities at Hanford; the new Pacific Northwest-Pacific Southwest Intertie Electrical Transmission Line; Remedial Action Projects at Rifle and Grand Junction in Colorado and at Weldon Springs in Missouri; and the Process Facility Modification at Hanford.

- Continuing analysis and coordination of Departmental responses to environmental regulatory proposals affecting energy activities and assessments concerning acid rain, energy technologies, and pollutants.

FY 1986 OBJECTIVES

In FY 1986 the Program plans to expand the overview and assessment efforts of Departmental activities to assure that environment, safety and health policies continue to be effectively implemented. The principal objectives in FY 1986 include:

- Developing better training guidance for reactor and nuclear facility operators to improve operational safety at DOE nuclear facilities.

- Developing improved methods for internal radiation dose assessments to assure compliance with radiation exposure limits recommended by National/International authorities.

- Issuing revised environmental protection, safety and health protection guidance, as required for Departmental operations, and conducting appraisals of ES&H performance of Headquarters program organizations and of the eight Operation Offices on approximately a biennial basis.

- Issuing quality assurance and unusual occurrence reporting guidance and appraising implementation of the guidance at eight field or program offices on approximately a biennial basis.

- Providing assistance to the Department's programs and projects in preparing National Environmental Policy Act (NEPA) documents and in securing other environmental approvals, permits, and clearances; and independently reviewing NEPA and other environmental documents to assure adequate compliance.

- Participating in environmental protection and regulatory working groups to assure that impacts of proposed environmental regulations and laws on energy policies and the energy industry are considered.

SUMMARY

The ES&H policies and independent overview have helped the Department to continue its excellent record of safety, health protection, and environmental compliance at the Departmental operational facilities.

The Environment, Safety and Health Program to date has assured that national energy policies and departmental plans, programs and operations have effectively addressed and expeditiously resolved environmental and safety problems. The proposed FY 1986 budget request provides the resources necessary to continue a strong independent Environment, Safety and Health overview of Departmental operations and activities.

I am prepared to answer your questions or comments on this program.

Attachments:
Charts on DOE Sites' ES&H performance statistics.

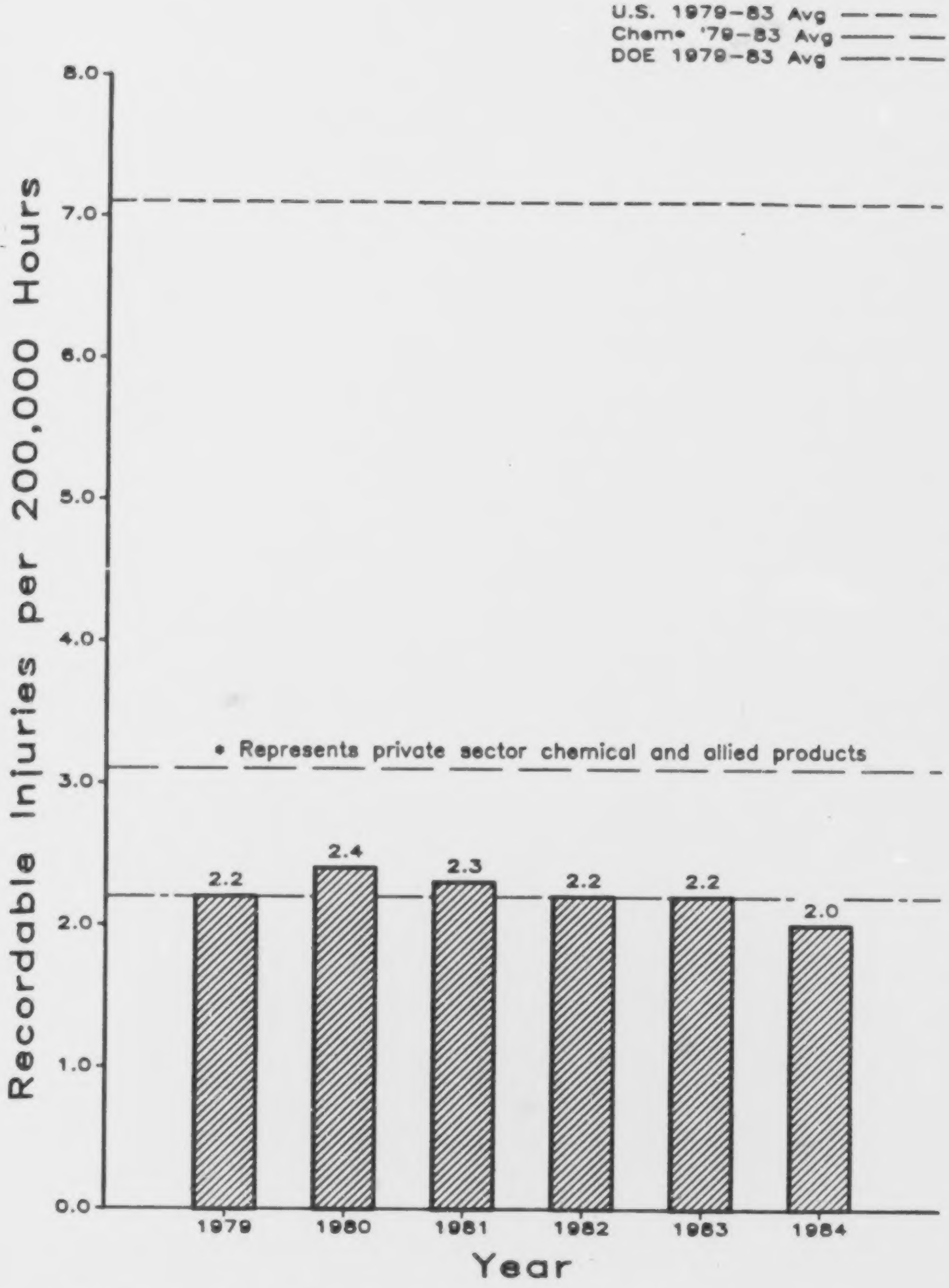


Figure 2. DOE and Contractor Recordable Injury Rates

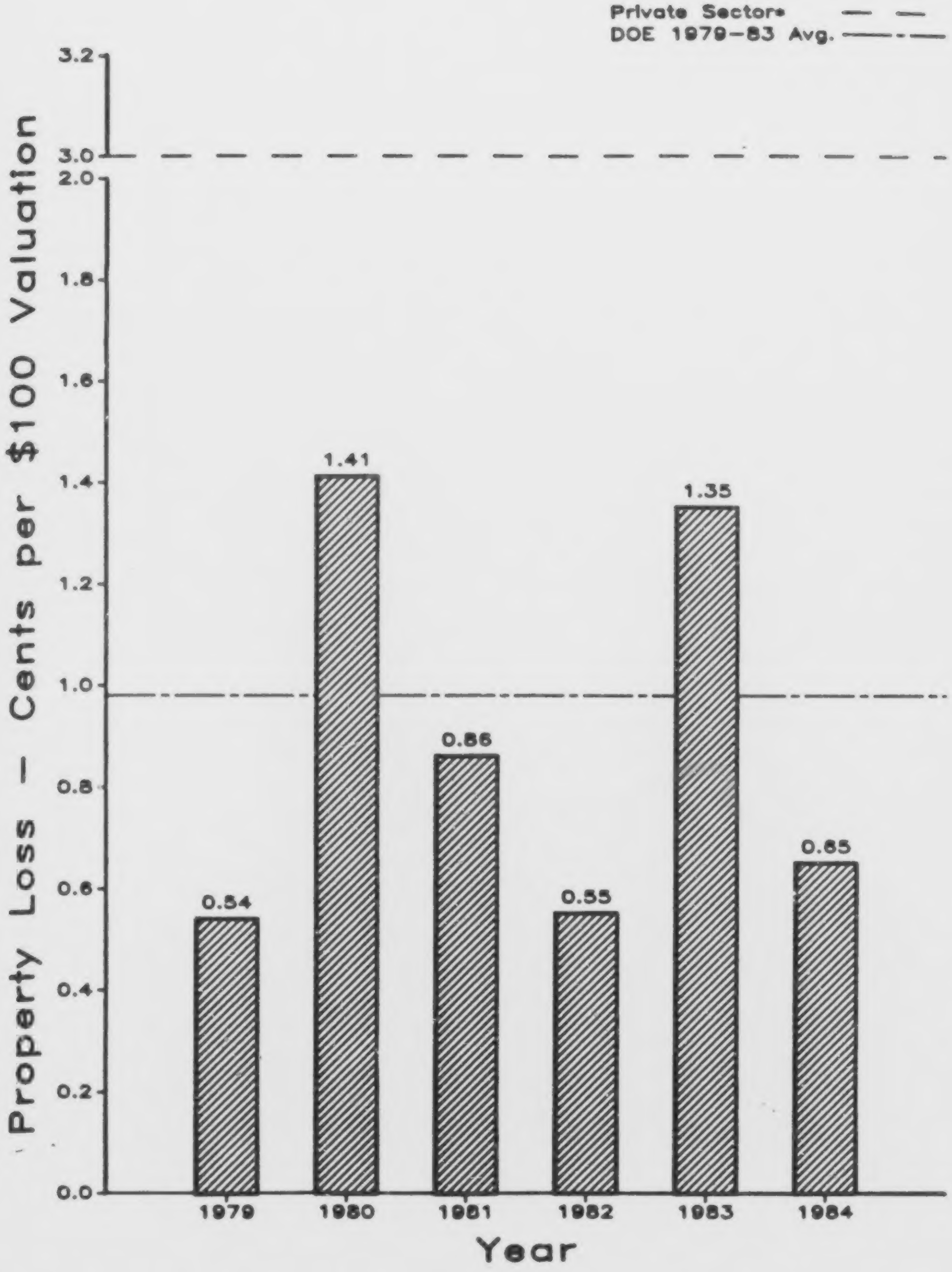


Figure 3. DOE and Contractor Total Property Loss Rates

* From discussions with personnel from the fire insurance groups

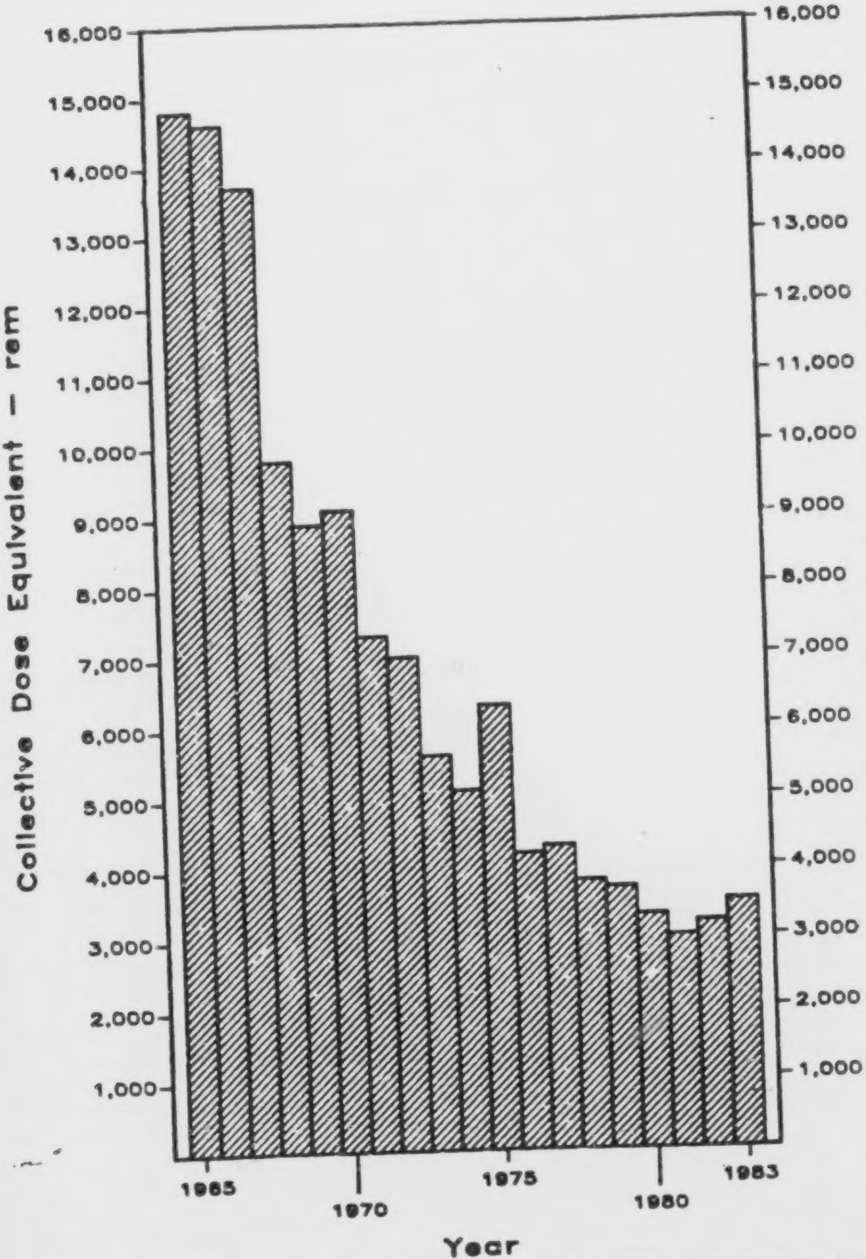


Figure 4. Total Collective Dose Equivalent for All DOE/DOE Contractor Employees Who Received an Exposure Greater Than 1 rem, 1965 – 1983

FIGURE 5. MAXIMUM INDIVIDUAL WHOLE-BODY DOSE FROM DEPARTMENT OF ENERGY OPERATIONS, 1979 THROUGH 1983

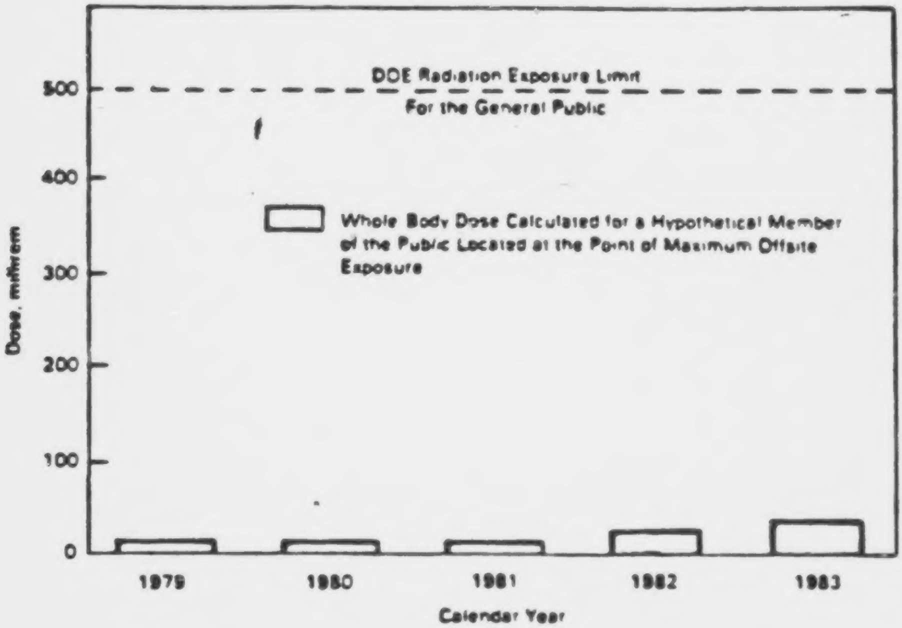
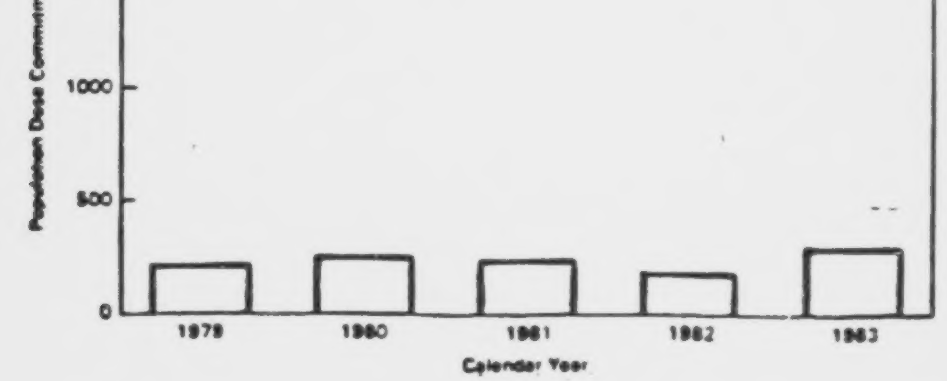


FIGURE 6. POPULATION DOSE COMMITMENT FROM DEPARTMENT OF ENERGY OPERATIONS, 1979 THROUGH 1983



Senator **Domenici**. Thank you very much. I have some questions, but I have until close to 3 o'clock myself, so I will yield to Senator Ford.

Senator **Ford**. I will be glad—I have just three or four questions to ask the Secretary, Mr. Chairman.

Mr. Vaughan, when Secretary Herrington testified on the fiscal year 1986 DOE budget, he provided for the record proposed budget figures showing 83 percent of DOE's net contribution to the deficit is attributable to the nuclear weapons program.

That is, if you take the proposed budget for each DOE program and then subtract any revenues or receipts raised by these programs, so as to arrive at the total net DOE contribution to the deficit, you find that the DOE weapons program would account for 83 percent of the DOE contribution to the deficit.

Your figures would treat the environment and safety budget as being entirely civilian.

Would you estimate how much of your budget request is actually devoted to activities associated with the nuclear weapons program?

Mr. **Vaughan**. That is very difficult to do with any precision, Senator. But it is certainly well greater than half of the activity. And I am going to guess somewhere on the order of two-thirds of the activity is related to the weapons program.

I base that not only——

Senator **Ford**. You are talking about two-thirds of the funding in every category as it relates to——

Senator **Warner**. I think he is talking about two-thirds of the entire Department of Energy budget.

Senator **Ford**. Is that what you are talking about?

Mr. **Vaughan**. No, sir. As I understood your question, as applied to this budget or activity, how much of our activity in environment, safety and health relates to nuclear weapons.

Senator **Ford**. That is right. Basically it appears on the face that it is solely civilian that you are talking about, and I wanted to get into the other part.

Mr. **Vaughan**. No, sir. A large chunk, somewhere around the order of two-thirds, I would say, is related to the weapons facilities because these facilities are the manufacturing facilities and the fabrication facilities for the Nation's nuclear arsenal, and we have to provide that day-to-day oversight.

So that is where a large part of the Department's facilities are located and devoted to those facilities.

Senator **Ford**. Let me then, if you would be so kind, Mr. Vaughan, to take my question and then submit a factual answer for the record. I would appreciate that very much.

Mr. **Vaughan**. Surely.

[The information follows:]

Approximately 70 percent of the Environment, Safety and Health program's budget request is related to the Department's Nuclear Weapons Program.

Senator **Ford**. On page 12 of your prepared statement there is a chart entitled "Total Collective Dose Equivalent for all DOE Contractor Employees Who Received an Exposure Greater Than 1 rem, 1965–83."

This chart shows that since 1965, the radioactivity dose equivalent has generally declined betwen 1965 and 1981. However, since 1981, the collective dose has increased, although a small amount, each year.

In the last year's budget hearing, Senator Domenici, our chairman, inquired about this same chart. Although the 1983 figures were not in it, Mr. Mares told the subcommittee that the 1983 data would not change the trend.

Hasn't the trend changed, and what will the 1984 figures really show?

Mr. VAUGHAN. I think my colleague's answer was substantially correct, Senator. If a trend meant a slight increase—and I think that is in fact what happened in 1983—that is explained by the fact that the production level of the nuclear weapons arsenal of the country is up; therefore, maintaining the same level of exposure, the same level of protection.

But where you have more workers and more time spent in the activity, when you accumulate the exposure, would cause an increase. So I would expect the 1984 to be about the same or slightly greater, but certainly nothing like the relationship of returning to these much higher figures in, say, 20 years ago, and the large drops there are the march of technology in improving worker protection and safety as well as some decline in production.

Senator FORD. Mr. Mares indicated this just happened to be one of those years and would go back down. But if you look at 1981, 1982, and 1983, the downward trend has reversed. And you say 1984 will follow the same path as 1981, 1982, and 1983.

Mr. VAUGHAN. I think these differences here are so minor, but I do think that what we are seeing is this slight upturn that is not a change in safety of the worker; it is reflecting the fact that there are more people involved in higher production levels.

And this is accumulating the total.

Senator FORD. On page 13 of your statement, figure 5 shows that the maximum individual whole body dose for DOE operations, 1979 to 1983, is also rising.

Do you have the same explanation for that one as you did the previous answer? Or do you have a different thought about this one, dosage per body?

Mr. VAUGHAN. Senator, here we are comparing—this is an apples and oranges comparison. In a sense, the first chart you were referring to is our workers.

Senator FORD. That is right. This is a whole body dosage I am talking about now.

Mr. VAUGHAN. But it is of a different population. This is at the perimeter of the facility or site. In other words, this is attempting to measure exposure outside the facility. So you are measuring two slightly different things, and so the explanation is substantially the same.

What you are seeing is very slight increases and they are measuring the fact that these facilities are being run in the last several years and for longer periods of time, higher production levels.

Senator FORD. Well, the trend is up in that one and it is also up in the other one. So both the trend lines are going up.

Mr. VAUGHAN. Slight changes upwards. Yes, sir.

Senator **Ford**. And this figure 5 is the fringes of the operation, that is the general public?

Mr. **Vaughan**. That is the general dividing line between plant and general public. Yes, sir.

Senator **Ford**. Wouldn't you be—or shouldn't you be a little bit concerned as to what is developing for the general public?

Mr. **Vaughan**. With this slight increase reflecting increased activity, I do not think we should be overly concerned. I do think we should watch this fairly carefully, and if we are going to maintain high levels of production for years on end, back to back, then we need to be increasingly concerned.

My understanding is that we are in a catch-up mode, and I would not expect—and I am not intimately familiar with the stockpile memorandum, Senator, so I don't know the precise figures—but I do not understand that we would expect them to continue at catch-up levels of production very long.

Senator **Ford**. Well, since you're in charge of safety, it would indicate to this Senator that you ought to be concerned about the increase, particularly as it relates to the general public and to the employees. And if your trend is beginning to rise, then I think—for three consecutive years—and on table 5, that is four consecutive years, five consecutive—well, four consecutive years from 1979 that the trend is up—it may not be alarming, but it does indicate that it is not coming down.

Mr. **Vaughan**. I think your choice of words perhaps fits the problem, Senator. It is not alarming. We should be and are concerned, but we are not alarmed.

Remember the Department's performance, particularly in the area of nuclear safety, and that is what these charts are measuring, has been very, very good. And it is the standard fundamentally.

So I do not think we are warranted in reaching the alarm level.

Senator **Ford**. One last question. Really, three quick questions.

One, do you think we have the best technology for keeping these particular figures in this area? Is the technology about as good as it is going to be?

Mr. **Vaughan**. I won't go so far as to say it is as good as it is going to be. I think we are employing generally the best techniques. Obviously, technology moves, particularly in these areas that have a high degree of focus and technological interest in this country.

So I will not go so far as to say the technology couldn't suddenly shift, in which case, if we have a sudden shift and are capable of doing significantly better, we should give it very serious consideration.

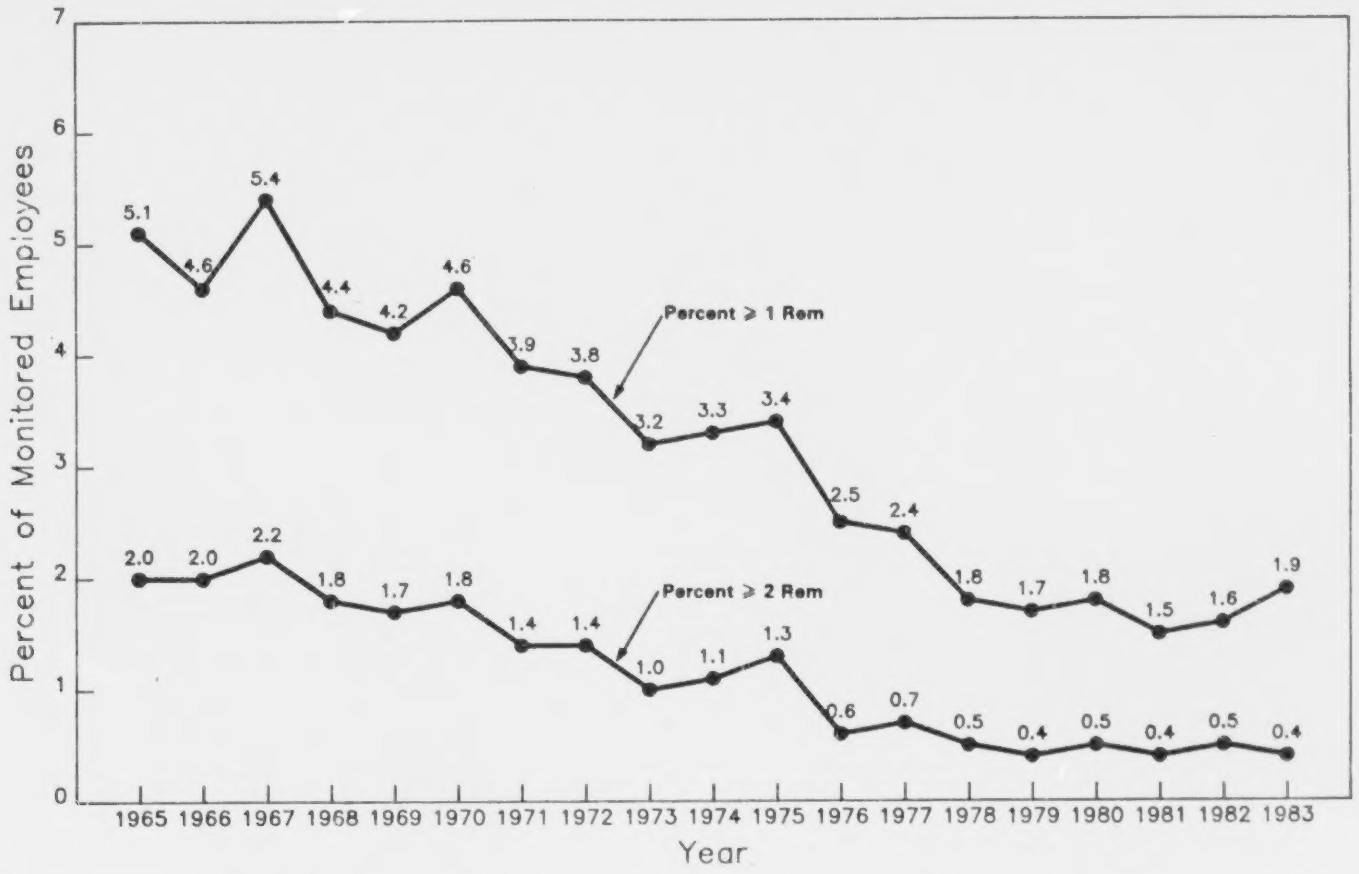
Senator **Ford**. Last year the Department provided a chart showing the percentage of employees receiving external doses greater than 1 rem and greater than 2 rem.

That chart is not included this year. Would you provide it for the record?

Mr. **Vaughan**. Yes, sir.

[The chart follows:]

A chart showing "Employee Exposure Doses Greater than 1.0 rem and Greater than 2.0 rem" is attached.



Percentage of Employees Receiving External Doses Greater than 1 Rem and Greater than 2 Rem (5 Rem per Year DOE Standard)

Senator FORD. Second, both you gentlemen are acting. Is there any time when we could anticipate the name being submitted for confirmation for Assistant Secretary of Policy, Safety, and Environment?

Mr. VAUGHAN. I can't answer that question for you, Senator. I can only tell you that the Secretary has an active study in the area of environment, safety, and health ongoing right now, and he expects response shortly, and I would expect him to take some action rather soon.

Senator FORD. Well, I am very pleased with some of the statements that are coming from the Secretary, and know that it is somewhat hard for a new individual to get his feet on the ground very quickly. But I am, on balance, pleased with the new Secretary, and I know that he will do the best he can.

But I just wondered about a time frame. But I am pleased, and I want that for the record, with several statements he has been making lately as it relates to his new position.

Thank you, Mr. Chairman.

Senator DOMENICI. Thank you, Senator.

He must like coal.

Senator FORD. Well, if he doesn't like it, he probably wouldn't say anything good.

Senator DOMENICI. Senator, I am going to yield to you, and ask my few questions last, but would you permit me to just ask one before I yield?

Senator EVANS. Please go ahead. I am sorry that I came in late.

Senator DOMENICI. Not at all.

Let me just ask with reference to the questions regarding the trend lines the Senator referred to, so we will make sure here for the public record that we understand, you have health and safety standards.

Mr. VAUGHAN. Yes, sir.

Senator DOMENICI. Now, these slight changes that you have referred to, the statistical changes, they are in no way putting these facilities, either within or without the Federal premise, in the position of exceeding or violating the health and safety standards, are they?

Mr. VAUGHAN. No, sir. Not close.

Senator DOMENICI. I will be glad to yield now to the distinguished Senator from Washington.

Senator EVANS. Just to follow through on that chart on page 12, I understand that is the total collective dose equivalent. Then that does not relate to the number of potential hours of exposure, or the workload in other words, to get to an equivalent per unit or per capita or per employee dose?

Mr. VAUGHAN. This is the total calculated across the entire population for whatever time. It is the total exposure. You cannot take this chart and go to the average employee exposure.

Senator EVANS. Why not? In other words, is this the total amount of dose for all employees for an entire year?

Mr. VAUGHAN. Yes.

Senator EVANS. Couldn't that be translated by knowing how many employees were working for how many hours? In other words, it doesn't tell me very much to know that in 1965 there was almost 15,000 and in 1983 there was somewhere between 3,000 and 4,000 unless I know whether there 2 million workers in 1 year and 10,000 the next year.

In other words, you could have some idea how much potential exposure there was, unless I don't understand the units that you are using or the relationship to the number of employees.

Mr. Vaughan. The purpose of this chart, Senator, was to show that the Department's—that back some years ago, we have employed and dropped drastically—you see some very sharp declines. And those sharp declines back in the past came from essentially improved technology, employed as it came on line.

Senator Evans. But I don't know that. If the amount on this chart is cut in half, and during that same period of time the number of employees are cut in half, have you really gained anything in terms of safety?

Mr. Vaughan. If that were the case, I guess you could reach that point.

We will be glad to furnish you—I don't have them with me——

Senator Evans. You see, this chart does not tell you that, and so you don't have any sense of whether the rate of exposure, unless you have some idea of what changes, if any, and you know, it might even make a steeper decline if the number of hours or employees were going up during this period of time.

But it is hard for me to know how well we are doing unless you have that element in it.

Mr. Vaughan. We will be glad to furnish for the record, Senator, some other charts to expand the number, to show on a number of bases, numbers of employees, numbers of hours exposed, that sort of thing that I think will give you a——

Senator Evans. Well, as a measure of potential danger of exposure, it seems to me that while this is an interesting chart, the other that would tell me whether an average employee during that period of time is in more or less danger would be a lot more indicative of what our Health and Safety programs have done.

Mr. Vaughan. I think I can give you the—we will furnish for the record information that will give you that.

It has improved steadily over the years and is exemplar.

[The information follows:]

AVERAGE DOSE EQUIVALENT FOR DOE AND DOE CONTRACT EMPLOYEES

Year	Number employees monitored	Number employees with measurable exposure	Average dose equivalent monitored mrem	Average dose equivalent measurable exposure mrem
1983	88,283	38,412	89	204
1982	85,324	36,356	84	198
1981	83,049	37,825	83	183
1980	85,465	40,411	87	183

Senator Evans. I am sure it has.

On this kind of thing, does the exposure tend to come from several—is a good share of this exposure from several incidents, or it does it tend to come a lot more gradually from just the continued scattered exposure during the course of working there?

Mr. VAUGHAN. The nature of radiation dose accumulation is such that there is a gradual accumulation from small exposures because it has a long life. But if you have a unique or single incident of high exposure, that also will accumulate and buck your particular level up higher.

Senator EVANS. I understand that.

Mr. VAUGHAN. And then where those levels—we have standards about—that relate to this kind of problem—and if an employee has been exposed accidentally, then we will change the work station, change the nature of the work, in order to take him out of exposure levels.

Senator EVANS. What I was trying to find out is what share of this total dosage comes from those rather intense incidents or accidents as opposed to those that are just in the normal course of daily activity?

Mr. VAUGHAN. Mr. Stern tells me here—certainly he is familiar with the data in the more recent years—and if you notice, this plot is for exposures greater than 1 rem. The vast majority of exposures result in dosages less than 2 rems.

We are not talking about single exposures at 100 or 50, that sort of thing.

Senator EVANS. So that would be, in essence, sort of the normal or close to normal exposure that you are running into.

Mr. VAUGHAN. And for data, Senator, the worker limit is five.

Senator EVANS. Five?

Mr. VAUGHAN. Five.

Senator EVANS. A specific plant that interests us out our way, the Purex plant at Hanford is an old plant. On occasion we read or hear of difficulties or activities. Do you have—and maybe this would better come from getting information for us—the record of contamination for workers in this plant as opposed to the general? Is this one more difficult because of its age?

Mr. VAUGHAN. Well, let me answer your questions in order, Senator. We certainly have the data by plant.

Senator EVANS. Yes, I am sure you do. I wouldn't expect that it would be readily available.

Mr. VAUGHAN. This one is one of the older plants, that is true. Whether this particular plant has had a worse than normal performance recently, it has had—it did have, in early January of this year, an incident. That is true. I am familiar with that. But I simply will have—I don't recall whether——

Senator EVANS. Surely. I would expect this would be something that if you could provide for me, it would be helpful; especially the relationship of this plant and perhaps the trends in the last few years, just to get an indication of whether there are any particular problems there as compared with other plant.

[The information follows:]

Exposure at Purex Plant at Hanford

From July 1972 to November 1983, the Purex Plant was on standby - some construction only. The plant started operations again in November 1983. Occupational Exposures for 1984 were an Average of 100 mrem/yr, and a Maximum of 500 mrem/yr for the 300 personnel. The off-site radionnuclide emissions from Hanford operations are too low to be measured in the ambient environment where people reside. However, doses are estimated on the basis of calculations using actual radionnuclide emissions from the facilities. In 1984 the estimated dose the maximally-exposed individual received off-site was 2 millirem. PUREX operations contributed less than 1% of .pa this dose. The estimated cumulative dose to the total population around Hanford was 5 person rems in 1984.

This compares with similar operations at DOE's Savannah River Plant's (SRP) F-area Production Canyon: The average exposure was 350 mrem per year and the maximum exposure 1235 mrem per year for the 130 radiation workers. The difference in exposure is due to the relatively high degree of maintenance activity necessary at

SRP as compared to PUREX. With startup in late 1983, PUREX has required very little maintenance (maintenance activities typically have higher radiation exposure potential), whereas maintenance in the F-Canyon production operations at SRP have constituted roughly 75% of that operations collective exposures. Both production facilities are operated under stringent radiological controls including as-low-as-reasonably-achievable (ALARA) policy, which promotes the reduction of unnecessary exposure. Radiological operations at both facilities are handled by remote control with substantial engineered safeguards. ALARA and close overview of individual worker exposure radiation doses are maintained well below established national limits (5,000 mrem per year), which are in turn conservatively set well below recognized thresholds for demonstratable recognized effects.

The PUREX plant from a health and safety stand-point is similar to the Savannah River Plant's (SRP) reprocessing canyons. PUREX plant was built after the SRP's plants and used basically the same safety design considerations. Both the PUREX and SR Plants use a canyon design utilizing remote replacement of radioactive equipment and piping. Therefore we don't anticipate any PUREX safety engineering problems which would cause higher radiation exposure than at the SR plants.

Senator EVANS. In the 1985 plan, you talked about the need to improve the criticality alarm system. Could you describe a little more fully for me just what that does and why it needs to be improved? What are the perceived deficiencies in the current activities?

Mr. VAUGHAN. We believe that this is an area, Senator, that would be fruitful for research and further technical development; that there has not in our judgment been as much development as we would like to have seen in automatic criticality warning devices, and it is for that reason that we propose to inquire in this area, hopefully to develop such detective techniques devices.

Senator EVANS. This is listed in your fiscal year 1985 program plans. The fiscal year is half over now. And you indicated that you were going to complete the development of an improved nuclear criticality alarm system.

I presume that if that is going to be the case, you must be well underway now. And do you still expect that during the course of fiscal 1985, you will complete the development of that improved capability?

Mr. VAUGHAN. Frankly, I will simply have to check whether we are precisely on schedule with that. I will be glad to respond immediately.

[The information follows:]

There are no well characterized neutron detectors for use in criticality alarm systems. DOE's nuclear materials processing facilities use gamma radiation detectors which cannot be used in criticality alarm systems where (1) the gamma background radiation is high (e.g., in cells of an irradiated fuel reprocessing plant); (2) the fissionable materials are in the metallic form, since most of the escaping energy from a criticality is carried by the neutrons rather than by the gamma radiation; and/or (3) there are large structures through the facility which would attenuate the gamma radiation emitted in a criticality accident.

The objective of this project is to develop and characterize a neutron detector which can detect neutrons over a broad range of incident energies (i.e., high energy (fast) neutrons from a criticality in a metallic system to low energy thermal neutrons from a criticality in a solution system).

The operation of the system is based on detection of neutrons, and activation of an evacuation alarm through an electronics system if the detected rate exceeds a preset value. The system will initiate an evacuation alarm for a minimum credible accident as defined in ANSI/ANS Standard 8.3 "Nuclear Criticality Alarm Systems."

Senator EVANS. Sure. This is more for my own information than anything else. You talk also in your fiscal 1985 program plans of continuing the coverage provided by the atmospheric release advisory capability and emergency response system for predicting effects of radiological releases.

Could you describe a little more fully what kind of a system is currently in place and how broad that coverage is, and how it relates to the Nuclear Regulatory Commission's assessment of the system?

Mr. VAUGHAN. The ARAC system is what you are referring to, Senator. This is a system that was developed for use during a nuclear incident, an unplanned accidental discharge, or that sort of thing.

And it is a program that has joint application, both to the Department's nuclear weapons activities, as well as it is useful to the commercial nuclear activities.

It is a predictive capability if you have a release as to where the plume and at what exposure levels that plume—what its contours would be. It is a highly computerized, very highly sophisticated calculation and predictive technique.

You have a very large data base for all known facilities that are located, and that allows you, if you have an incident at a known site which you have loaded into the data base, that allows you very quickly to simply plug in the meterological conditions, the level of release, and predict on a continuous basis where that dangerous plume may go.

This activity actually was used in the Three Mile Island incident some years ago. It was still in its infancy, but it turned out to be quite accurate.

If you have a situation where you have a source that is mobile and something happens to it, then you would have to feed, since you have no data base, and the capability would have to be accurate—it would be a little longer response time.

Senator EVANS. You say you currently have all the currently known standards——

Mr. VAUGHAN. U.S. standard fixed sites are loaded into the system, and the capability to read in meteorological—that sort of data—and the only on-ground from the incident that would have to be plugged in then would be the release level for known sites.

For mobile forces, we would have to go on site, measure, and feed back. The computer, theoretical, the brains behind this operation are essentially located at Lawrence Livermore Laboratory.

Senator EVANS. I notice that you have listed fiscal 1985 program plans, and then the fiscal 1986 objectives which are broader and not quite so specific.

What is your timing? When do you develop your program plans for fiscal 1986? We are now in fiscal 1986 authorization budget cycle. At what point will you have more specific program plans that you intend to carry out during fiscal 1986?

Mr. VAUGHAN. We would expect the normal cycle would call for the program plans to be put in final format about at the time the fiscal year changeover occurs. And then they obviously would have to be adjusted if there are big differences between what you anticipated and what the Congress sees fit to appropriate, either way.

And so there usually will be—oh, a month, 2 months before you—depending on how complicated the program is and how far this gap, how large this gap might be.

Senator Evans. Thank you, Mr. Chairman.

Senator Domenici. Thank you, Senator.

Mr. Secretary, I am not going to go into any of the detailed questions on your budget. We can do that with questions for the record. What I would just like to do is just give you a sense of my concern.

I believe that you have to be ever concerned and vigilant with reference to your regulatory functions. You have done such a good job and been on the cutting edge of almost all new technology. And I am kind of concerned that we are going to get kind of lazy because of that and get started one of these days with an event.

And I just want to ask a few questions. You indicate in your statement on page 2 that Washington has the oversight responsibility for what you call line organizations, which have the responsibility for safe environment and for safe, environmentally sound operations.

So I would just like to ask you, do you know where the buck stops? Let me give you an example. If some contractor is not performing properly, who is responsible?

Mr. Vaughan. Well, I think ultimately, Senator, obviously I guess you have to say that the Secretary is ultimately responsible, but obviously he can't have day-in knowledge.

What he has, he has his line programs out to the field office. That is where the first and most important part of the responsibility starts and essentially stops, other than checking to be sure that they are performing this function.

And I think that parallels, certainly from my experience, effective management of these kinds of activities—environment, safety and protection—in industry. The best of operations occur where you have a local plant manager and every level of management accountable as part of their jobs.

I think it is a very bad system that somehow has headquarters responsible and the field not responsible, that sort of thing. This program is set up that way.

Senator Domenici. I understand. But there is a very, very big difference between DOE and its operations and a corporation and its operations, or there usually is, because you do a lot of your work through contractors that are not really you.

Sandia Lab, Kirtland, Los Alamos Scientific Lab. In a real sense, those are contractors. They are bound by your regulations and as I understand the law, you are responsible, the Department, for the safety there.

So let me just ask, how often does DOE conduct safety or health inspections at a lab facility? Do you have your own inspectors that inspect lab facilities that are independent contractors?

Mr. Vaughan. The nearest field operation, Albuquerque Operations Office, would have the responsibility to check on safety on a continuing basis of the contractor, if it was Sandia, or whoever was performing the work. The Department's independent oversight gets around to all facilities at least every 2 years on a check on the system that is checking the contractors and our own activities.

Senator DOMENICI. Do you ever conduct unannounced inspections of these kinds of facilities, or is this just a regular overseeing of whether they are doing it right?

Mr. VAUGHAN. When the inspection comes from the local field office—and as you know, I use this term local field office—these are fairly large operations in most cases. They are essentially unannounced, continuous.

The ones from Washington, candidly, tend to be announced. While they may not be announced 1 year or 6 months in advance, the mere scheduling of travel, et cetera, amounts to the fact that they are fundamentally known a short time before the inspectors arrive in the field.

Senator DOMENICI. Does the DOE report the results of facility inspections? And if they do, are there any recommendations included in the inspection reports?

Mr. VAUGHAN. Yes; here are corrective actions. And I am talking for now at every level of inspection, both field office and for other checks that come from Washington. If deficiencies are found or, perhaps more accurately, when they are found, then there are recommendations as to the course of action and then there are followup inspections about the recommended courses of actions.

Senator DOMENICI. If a facility does not comply with environmental or safety health standards, how is that reported?

Mr. VAUGHAN. It would be reported as not complying.

Senator DOMENICI. But how?

Mr. VAUGHAN. I am not sure I understand your question there, sir.

Senator DOMENICI. Is there an official way, mechanically official way that noncompliance is reported? And does that go to the national headquarters, or is that handled regionally?

Mr. VAUGHAN. If there is a noncompliance at the local level and it is a fairly routine matter that is easily corrected, it will not go instantaneously to Washington. If there is something that amounts to an unusual occurrence, that will go direct to Washington through the emergency operations, Senator, as an instantaneous report.

But a judgment is made on the spot in the field that this incident has enough danger either to life, limb, property or a program itself that it would meet the standards of an unusual occurrence.

Senator DOMENICI. Do you have any incentives built into this program to encourage high standards with reference to health and safety? And, conversely, do you have any disincentives that discourage or even penalize the below-standard performance?

Mr. VAUGHAN. I think we have very effective incentives with respect to contractors through the award fee concept, and so you have, I think, a good mix of incentives and disincentives.

It is more difficult in an area that I think needs constant attention within the Government system, where you do not have direct compensation on a reward/fine basis, so to speak, or lack of reward; it is harder to do.

And there the purpose of having the independent oversight is so that the Secretary at least can be assured that he has an independent oversight out of the program, so that at least the odds are on his side that there will be a report that comes through.

And I think that is an effective way to do it.

Senator DOMENICI. Let me just close first by saying we will submit some specific questions regarding budgeting aspects. Answer them at your convenience.

And I just want to stress with you that many of us here have been strong advocates of the Department of Energy maintaining its own standards. To the extent that we can continue that, many of us are going to strive to keep it that way.

The one thing that is constant around here are efforts to put all of your health and safety, both the rulemaking and the inspection, into either Nuclear Regulatory Commission or EPA, as you well know.

I just want to say to you that you have a very proud record and it has permitted us to maintain this posture, which many of us think is absolutely imperative. But all we need are a couple slip ups, and you understand, everyone has those, but you can't afford to have them very often, and you can't afford to have any sloppy process that predates them or we will certainly lose this aspect of regulatory diversity which we think has been not only healthy, in that there is a pretty good competition, and you do as well or better than the others most of the time.

We also think it is imperative because national security is involved in a number of these facilities, and clearly we need the kind of independence that we have been able to maintain. So long as we have a Department that is vigilant, I am sure we can maintain it. It is a rough process.

As you know, we have just completed Superfund, and in that we are now going to have to inventory off military reservations and off facilities like big labs all of those kind of Superfund activities, even though heretofore we have done it ourselves.

You understand that inventory was in process on an agreement between a couple of agencies. Clearly, when those kinds of things occur, we have to end up being on the side of having done everything possible to do what is right.

So I want to urge that you continue the emphasis, and wherever you have any doubts, and if that is related to resources, that you call it to our attention because this is one area that we clearly do not want to neglect activities based upon personnel or available technology.

We are surely able to find the money to do these kinds of things if your Department constantly reminds us and is doing the job right. I have no reason to suspect the contrary. From time to time, I get worried about contractors as compared with your own facilities, because I think frequently there is a little bit less of a connection, a little bit less of a real solid line as to who is responsible.

But I am just going to close by saying that I would, personally, appreciate it if you would remind the Secretary that we are interested in this and concerned about it. The sooner he can get his staffing made permanent, the better off we will all be. And I understand your problem.

But I will close with that and thank you for your testimony. Unless the Senator from Washington has anything further, we will stand in recess.

Thank you very much.

[Whereupon, at 3:02 p.m., the hearing was recessed, subject to the call of the Chair.]

APPENDIX I

Responses to Additional Questions

POST-HEARING QUESTIONS AND ANSWERS

RELATING TO THE

APRIL 17, 1985, HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

WITNESS: WILLIAM A. VAUGHAN
ACTING ASSISTANT SECRETARY FOR POLICY, SAFETY, AND ENVIRONMENT

QUESTION FROM SENATOR DOMENICI

Question 1: Just to continue with the discussion we had yesterday concerning DOE's performance standards when dealing with contractors, do you have a mechanism whereby employees of DOE contractors can come directly to the Department if they feel there is a violation of guidelines? Are these employees or their unions consulted when DOE develops such guidelines?

Answer: Yes, we have a mechanism whereby contractor employees (or their representatives) may submit either written or oral complaints directly to the DOE contracting officer or his representative when they believe that DOE-prescribed OSHA standards are being violated. The specific procedures for submission and resolution of these complaints were written to be consistent with the safeguards built into the Occupational Safety and Health Act of 1970 and are detailed in Chapter II of the DOE Order 5483.1A "Occupational Safety and Health Program for DOE Contractor Employees at Government-owned Contractor-operated Facilities."

DOE procedures afford employees or their unions the opportunity to participate in the "...promulgation, amendment or revocation..." of DOE-prescribed OSHA standards. More specifically: "Contractors and contractor employees (or representatives thereof) may submit written requests...that new standards be promulgated to cover occupational safety and health hazards not addressed by the existing DOE-prescribed OSHA standards,..." Further, "Field organizations, contractors, contractor employees and representatives thereof, whose working conditions would be affected by the standard, shall have the opportunity to review and comment on proposed or temporary standards before their promulgation or amendment as final standards."

QUESTION FROM SENATOR DOMENICI

Question 2:	What is being done to strengthen the role of the Environment, Safety, and Health program office within DOE? Considering the public's heightened attention to matters of safety, health, and the environment, would you agree that this office merits elevation to an autonomous division within DOE?
Answer:	In July 1984, the Assistant Secretary for Policy, Safety, and Environment (ASPE) was charged by the Secretary with the task of improving the DOE Headquarters independent safety organization. This included the necessity to critically examine and enhance the responsibilities and authorities given to that organization in the DOE ES&H Orders and the need for organizational changes.

To that end, the ASPE established a task force under the leadership of Dr. Bill Shipp, Director, Technology Management Division, Chicago Operations Office, to revise the DOE Orders to initiate the actions needed to strengthen the Headquarters independent safety function. These actions resulted in proposed major changes to DOE Environment, Safety and Health Orders.

A summary of the major changes made to strengthen the Deputy Assistant Secretary for ES&H role are provided below.

The DOE ES&H Orders were revised to include:

I. ASPE review and concurrence of:
    A. Initial startup of DOE reactors and high hazard nuclear facilities.
    B. Initial startup of DOE moderate hazard nuclear facilities on a select basis.
    C. Safety Analysis Reports for these facilities because of the responsibility noted in I(A) and (B) above.

II. ASPE responsibility and authority to:
    A. Provide advice to the Secretary on the prioritization of the Department's major ES&H upgrades for the purpose of initiating and, ultimately, establishing the Departmental, OMB and Congressional budget requests. This advice would be based on the recommendations contained in the cognizant Field Office Managers' and Program Secretarial Officers' budget requests.
    B. Allow the Deputy Assistant Secretary for Environment, Safety and Health, acting as the Department's "Safety Officer," to have direct access to the Secretary on all

matters of safety significance which can have adverse effects on the Department's safety program.

C. Conduct Technical Appraisals of the Department's Category A reactors and high hazard nuclear facilities which would be coordinated with the field and Headquarters program and safety offices and include their participation.

D. Participate on scheduled field office functional appraisals of contractor facilities/operations.

III. The authority of the Deputy Assistant Secretary for Environment, Safety and Health, acting as the Department's "Safety Officer," to recommend termination of operations under certain circumstances.

The above is not an inclusive list of modifications but does serve to illustrate the modifications found necessary by the task force to achieve a viable and strong ES&H organization. The Orders were revised and coordinated with the field and Headquarters offices over the period from September 1984 to April 1985. Issuance of the Orders is anticipated shortly.

Concurrent with the final revisions to the Orders, Secretary Herrington requested a management study of the ES&H function. The study has recently been completed and is under review by the Secretary's office. The Secretary's office is expected to make a decision on this in the very near future.

QUESTION FROM SENATOR MCCLURE

Question 1: Facilities such as the Federal Materials Production Center in Fernald, Ohio, that are sole sources of certain defense-related materials, are a vital link in our weapons complex. Thus, when such a facility is shut down due to an unplanned release, this not only affects the health and safety of the local community and the surrounding environment, but it also has a significant impact on our national security. In such cases, what mechanisms are available to expedite the procedures necessary to restore the facility to full, safe, and reliable operation? What is done to prevent the recurrence of a similar event? What responsibilities and authorities does the division of Environment, Safety, and Health have to assure that the facility restoration proceeds smoothly and expeditiously?

Answer: With regard to your question about mechanisms which are available to expedite the procedures necessary to restore the Feed Materials Production Center at Fernald, Ohio, to full, safe, and reliable operations after an unplanned release, the Department of Energy (DOE) has an Order which defines the actions to be taken when such unplanned releases occur. This Environment, Safety, and Health Order, DOE 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements," has the following pertinent objectives:

1. To investigate and evaluate occurrences to determine their causes and the appropriate measures to prevent recurrences and improve the safety of DOE and DOE contractor operations.

2. To obtain early, complete, and factual information on occurrences as a basis for: (a) reports to the Secretary, Congress, and other Federal agencies; and (b) where appropriate, informing the public.

3. To assure the gathering of adequate information on which to base management action.

By implementation of this procedure, DOE line management can take the necessary corrective actions to attain safe operations. In the case of the September-December 1984 Fernald Plant 9 excessive uranium emissions, the Oak Ridge Operations (ORO) Manager appointed a three member investigation board in accordance with DOE 5484.1 on December 10, 1984. The investigation board held briefings with the National Lead of Ohio, Inc. (NLO, Inc.) management on December 15 and 19, 1984, and January 18, 1985, to advise them of the pertinent facts discovered during the investigation. The formal investigation report and the recommendations of the board were submitted to the Manager, ORO,on February 7, 1985. Oak Ridge transmitted a copy of the final investigation report to the Plant Manager of NLO, Inc., with a copy sent to the DOE Headquarters

Office of Operational Safety, on February 8, 1985. In this letter, Oak Ridge Operations required that NLO, Inc. immediately implement the recommendations which pertained to NLO, Inc.

With regard to your question as to what is being done to prevent recurrence of a similar event, the DOE will analyze the lessons learned from this unplanned release, and to the extent that these lessons have broader implications for the DOE system, guidance will be disseminated to strengthen affected Environment, Safety, and Health (ES&H) programs and prevent similar events.

With regard to the responsibilities and authorities ES&H has to assure that the Fernald facility restoration proceeds smoothly and expeditiously, ES&H will assist the line organizations by assessing the adequacy of the corrective actions and the resultant ES&H program.

Presently, the following steps are being taken to strengthen the ES&H program for the Fernald facility by:

- Improving the management control system to assure that cognizant line management, operators, and safety professionals are committed to effective control strategies which maintain uranium emissions as low as reasonably achievable and are knowledgeable in reporting requirements for uranium emissions.
- Improving the inspection and monitoring programs which determine the radioactive material emissions from the ventilation systems.
- Improving the maintenance and state-of-repair of the baghouse filter system, especially by use of an improved quality assurance program.

  Further, the Department is proceeding with plans to replace the primary baghouse dust collectors with units of improved design, and to provide secondary high efficiency particulate air filter systems on the ventilation systems for processes with the largest particulate loss potential.

QUESTION FROM SENATOR EVANS

Question 1: On page 12, the Collective Dose Equivalent--rem table, please provide a breakdown of the cumulative total by:

a) number of employees (DOE and DOE contractor) from 1965 through 1983;

b) number of man-hours worked.

Answer: Table 3 from the DOE's Annual Report on Radiation Exposures for DOE and DOE Contractor Employees - 1983 is attached which provides a breakdown of the number of employees receiving exposures in various dose-equivalent ranges.

TABLE 3. Distribution of Whole-Body Ionizing Radiation Exposures for DOE/DOE Contractor Employees, 1965-1983

	Number of Employees Receiving Exposures in Each Dose-Equivalent Range (rem)													
	0-1(a)													Total Employees
Year	<Meas.	Meas.-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	>12	Monitored
1965	128,360		4,158	1,704	515	294	70	32	26	25	22	6	2		135,214
1966	131,522		3,706	1,630	593	313	88	47	24	6	2			1	137,932
1967	102,510		3,472	1,572	555	168	35	29	23	17	4	1			108,386
1968	103,206		2,799	1,408	425	144	3	1							107,986
1969	98,625		2,354	1,313	335	86	4					1			102,718
1970	92,105		2,698	1,329	279	158	5	4	2		1				96,581
1971	90,640		2,380	888	275	118	8	3				1		2	94,315
1972	86,077		2,130	929	219	95	8	2							89,460
1973	89,071		1,944	727	172	60	2	1							91,977
1974	43,184	32,500	1,667	688	149	40	4								78,232
1975	43,310	42,141	1,846	753	232	142				1					88,425
1976	40,083	47,886	1,679	475	70	6	1								90,200
1977	43,017	49,948	1,579	545	103	23			1	2				2	95,220
1978	44,898	55,296	1,323	439	53	11									102,020
1979(b)	50,003	53,235	1,286	416	33	10	1							2	104,986
1980	45,054	38,895	1,113	387	16										85,465
1981	45,224	36,561	967	263	29	5									83,049
1982	48,968	34,949	1,010	313	56	28									85,324
1983	49,871	36,768	1,270	294	49	31									88,283

(a)Separation of data prior to 1974 is unavailable.
(b)The 1979 data differ slightly from those listed in the original 1979 report because of an error in the dose-equivalent calculation by a contractor.

QUESTION FROM SENATOR EVANS

Question 2: PUREX Plant:

a) Please provide a breakdown of the national, cumulative figures on a PUREX, or Hanford reservation basis (the collective dose equivalent figures);

b) Provide a comparison of the PUREX Plant with other similar DOE plants in different locations;

c) Is the PUREX Plant unique because of its relatively old age, from a health or safety standpoint?

Or are the safety engineering problems similar to other DOE plants?

Answer: a) From July 1972 to November 1983, the Purex Plant was on standby - some construction only. The plant startec operations again in November 1983. Occupational Exposures for 1984 were an Average of 100 mrem/yr, and a Maximum of 500 mrem/yr for the 300 personnel. The off-site radionnuclide emissions from Hanford operations are too low to be measured in the ambient environment where people reside. However, doses are estimated on the basis of calculations using actual radionnuclide emissions from the facilities. In 1984 the estimated dose the maximally-exposed individual received off-site was 2 millirem. PUREX operations contributed less than 1% of this dose. The estimated cumulative dose to the total population around Hanford was 5 person rems in 1984.

b) This compares with similar operations at DOE's Savannah River Plant's (SRP) F-area Production Canyon: The average exposure was 350 mrem per year and the maximum exposure 1235 mrem per year for the 130 radiation workers. The difference in exposure is due to the relatively high degree of maintenance activity necessary at SRP as compared to PUREX. With startup in late 1983, PUREX has required very little maintenance (maintenance activities typically have higher radiation exposure potential), whereas maintenance in the F-Canyon production operations at SRP have constituted roughly 75% of that operations collective exposures. Both production facilities are operated under stringent radiological controls including as-low-as-reasonably-achievable (ALARA) policy, which promotes the reduction of unnecessary exposure. Radiological operations at both facilities are handled by remote control with substantial engineered safeguards. ALARA and close overview of individual worker exposure radiation doses are maintained well below established national limits (5,000 mrem per year), which are in turn conservatively set well below recognized thresholds for demonstratable recognized effects.

c) The PUREX plant from a health and safety standpoint is similar to the Savannah River Plant's (SRP) reprocessing canyons. PUREX plant was built after the SRP's plants and used basically the same safety design considerations. Both the PUREX and SR Plants use a canyon design utilizing remote replacement of radioactive equipment and piping. Therefore we don't anticipate any PUREX safety engineering problems which would cause higher radiation exposure than at the SR plants.

QUESTION FROM SENATOR EVANS

Question 3: Criticality Alarm System - Provide some general material on why the improvements are necessary, as well as some general material on the operations of the system.

Answer: There are no well characterized neutron detectors for use in criticality alarm systems. DOE's nuclear materials processing facilities use gamma radiation detectors which cannot be used in criticality alarm systems where (1) the gamma background radiation is high (e.g., in cells of an irradiated fuel reprocessing plant); (2) the fissionable materials are in the metallic form, since most of the escaping energy from a criticality is carried by the neutrons rather than by the gamma radiation; and/or (3) there are large structures through the facility which would attenuate the gamma radiation emitted in a criticality accident.

The objective of this project is to develop and characterize a neutron detector which can detect neutrons over a broad range of incident energies (i.e., high energy (fast) neutrons from a criticality in a metallic system to low energy thermal neutrons from a criticality in a solution system).

The operation of the system is based on detection of neutrons, and activation of an evacuation alarm through an electronics system if the detected rate exceeds a preset value. The system will initiate an evacuation alarm for a minimum credible accident as defined in ANSI/ANS Standard 8.3 "Nuclear Criticality Alarm Systems."

QUESTION FROM SENATOR BINGAMAN

Question 1: The Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico, was designed for the permanent storage of low-level and transuranic wastes and for the temporary storage of some high-level wastes as scientific experiments are conducted. As DOE officials have already emphasized in previous testimony before the Senate, the WIPP site is not being designed for the permanent disposal of high-level waste, nor has the site been characterized for such permanent disposal. I am especially concerned with several health and safety issues related to WIPP.

a) As WIPP is constructed, can we receive assurances that there will be no separate or unique set of standards for evaluating the quality of construction at WIPP, especially with respect to emergency barriers between the waste and the salt walls? Will the standards be inferior to existing NRC and EPA standards for other waste handling facilities?

b) What type of quality assurance can be expected for construction materials at WIPP? Will the standards for this project be equivalent to existing NRC standards for other waste handling facilities or will they be less rigid?

c) Can we receive a commitment from the agency that information regarding the risks associated with transporting both high-level and transuranic wastes will be provided to the state of New Mexico as soon as possible? As I understand, the State has requested this information be provided quickly in light of the expedited construction schedule at WIPP.

Answer: (a) A number of research and experimental programs are under way at WIPP to address the technical problems of "emergency barriers between the waste and the salt walls" under the general context of barriers as defined by the EPA in recent draft regulations (40 CFR 191). DOE must comply with applicable EPA standards. The WIPP standards are in no way intended to be inferior to the EPA requirements. WIPP's goal is the same as NRC's in assuring a safe environment. In addition, all experimental programs at WIPP are subject to review and coordination with the State of New Mexico. A meeting was held in April with the State of New Mexico, Environmental Evaluation Group, to coordinate issues concerned with the WIPP underground barriers experimental program.

While it is not clear at this time that an additional barrier is needed which would be placed over and around the waste packages, additional research is under way at WIPP to see if a redundant barrier would provide significant added confidence.

(b) With respect to your concern regarding quality assurance of construction materials, the quality assurance program for the design and construction of the WIPP facility complies with the DOE quality assurance program requirements for nuclear facilities. This program is equivalent to, and addresses, the same basic quality assurance program elements required for the commercial waste handling facilities as described in 10 CFR Part 60, Subpart G.

The quality requirements for construction materials are derived from the design specifications. The design classification system has been reviewed by the State of New Mexico's Environmental Evaluation

Group, which has provided its general agreement as to its application to the WIPP project.

The WIPP quality assurance program verifies that the procurement of construction materials is in compliance with the design documents. The State of New Mexico's Environmental Evaluation Group has a quality assurance representative at the WIPP site reviewing our total construction program, and all of the State's quality assurance reports, thus far, have indicated concurrence with the WIPP's construction quality program.

(c) The Department is committed to providing to the State of New Mexico, as soon as possible, an assessment of the risks associated with transporting both high-level and transuranic wastes. A preliminary transportation analysis for contact-handled transuranic (CH-TRU) waste was prepared and reviewed by the State and is now being revised to include updated information on radionuclide distributions in the transuranic waste and to address the State's comments. An analysis is being performed which will provide the State with information concerning the transportation of remote-handled transuranic (RH-TRU) waste. A similar analysis will address the transportation of defense high-level waste (DHLW) to WIPP for use in the planned DHLW experimental program. The CH-TRU analysis is nearing completion and will be provided to the State in the near future. The RH-TRU analysis is progressing and will be provided to the State shortly after the submission of the CH-TRU analysis. The transportation analysis for DHLW will also be performed and provided to the State as soon as practicable.

It should be noted that although there are some construction activities which are ahead of schedule, the agency position on the schedule for receipt of waste at WIPP has not changed and remains scheduled for the fall of 1988.

DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS—FISCAL YEAR 1986

(Energy Research Programs)

TUESDAY, APRIL 30, 1985

U.S. Senate,
Subcommittee on Energy Research and Development,
Committee on Energy and Natural Resources,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:30 a.m., in room SD-366, Dirksen Office Building, Hon. Pete V. Domenici presiding.

Present: Senators Domenici, Warner, Hecht, Evans, Bumpers, and Bingaman.

Also present: Paul Gilman, professional staff member; Benjamin S. Cooper, professional staff member for the minority; and James T. Bruce, counsel for the minority.

OPENING STATEMENT OF HON. PETE V. DOMENICI, A U.S. SENATOR FROM THE STATE OF NEW MEXICO

Senator **Domenici**. The subcommitee will come to order.

We have Dr. Alvin Trivelpiece, Director of the Office of Energy Research, to testify on the Department's budget request for energy research programs.

We also have one public witness who will give his comments when the doctor concludes.

I am on a very difficult time schedule and I'm sure you all are, too. So let's proceed and hear your testimony. You have prepared testimony?

Dr. **Trivelpiece**. Yes; I do, Mr. Chairman.

Senator **Domenici**. It will be made part of the record. We will proceed, and then we will take the other witness if Senator Ford does not arrive in time. He is having a markup on Conrail which is very important to him, and we'll leave the record open if he doesn't get here for questions he might have.

Please proceed.

STATEMENT OF DR. ALVIN W. TRIVELPIECE, DIRECTOR, OFFICE OF ENERGY RESEARCH, DEPARTMENT OF ENERGY

Dr. **Trivelpiece**. Mr. Chairman, I'd like to be uncharacteristically brief this morning. I know you know a great deal about these programs, the characteristics of them and that the individuals involved in them are excellent. I would not presume to prevail on your sense of humor by lecturing you on the difficulties with the budget this year. You only have to read the newspaper to be aware of how you're involved in the problems and so on.

The collection of programs that we're talking about here today sums to about $1.35 billion and the compromise between deficit control and trying to maintain the program activities has resulted in about a $46 million reduction in that level. We have tried to accommodate to that reduction as best we can by preserving the core programs and the excellent scientists in other activities that are going on, and defer some construction activities.

These programs have produced excellent results. Many of the Nobel prizes and so on come from this broad collection of programs the Department manages.

I think, as I said, I'll be uncharacteristically brief this morning. And if you have questions, I'd like to proceed to those.

[The prepared statement of Dr. Trivelpiece follows:]

Statement of Alvin W. Trivelpiece

Director of Energy Research

Department of Energy

before the

Subcommittee on Energy Research and Development

of the

Senate Energy and Natural Resources Committee

April 30, 1985

Mr. Chairman and Members of the Subcommittee:

It is a pleasure to appear here today to present the FY 1986 budget request for several of the programs supported by the Office of Energy Research (ER). Today I would like to discuss the following programs: High Energy and Nuclear Physics, Basic Energy Sciences, Biological and Environmental Research, Energy Research Analysis, University Research Support, University Research Instrumentation, and Multiprogram Laboratories Facilities Support. I will discuss the Magnetic Fusion Energy program at a later hearing. The High Energy and Nuclear Physics programs are under the General Science and Research appropriation. All of the other programs are under the Energy Supply R&D appropriation. The FY 1986 budget request for all ER programs is shown in Table 1.

This budget request reflects the goal and strategies set out in the Fourth National Energy Policy Plan (NEPP-IV). As stated in NEPP-IV, the goal of our national energy policy is to foster an adequate supply of energy at reasonable costs. The strategies for achieving this goal are: (1) to minimize Federal control and involvement in energy markets while maintaining public health and safety and environmental quality, and (2) to promote a balanced and mixed energy resource system.

Table 1
Office of Energy Research
Summary by Program
($ in millions)
Budget Authority

	FY 1985 Estimate	FY 1986 Request
General Science & Research		
High Energy Physics	$545.6	$510.1
Nuclear Physics	182.8	172.9
General Science Program Direction	2.2	2.4
Subtotal	$730.6	685.4
Energy Supply - R&D		
Basic Energy Sciences	$422.6	409.8
Magnetic Fusion Energy	437.0	390.0
Biological & Environmental Research	190.5	186.3
Energy Research Analysis	3.0	2.7
University Research Support	11.2	9.7
University Research Instrumentation	5.0	4.5
Multiprogram Laboratories Facilities Support	33.2	51.2
Advisory & Oversight Program Direction	2.8	2.9
Policy and Management	0.5	0.5
Subtotal	$1,105.8	$1,057.6
Total ER	$1,836.4	$1,743.0

NEPP-IV also stresses the need to: (1) increase our basic understanding of nature and matter, (2) advance the frontiers of scientific and engineering knowledge that forms the basis for technological innovation, (3) assess the potential human health and environmental effects associated with development and use of energy technologies, and (4) transfer new knowledge to the private sector where it can be developed further and applied. The programs that I will discuss today accomplish all of these things.

At this point I would like to discuss each of the programs mentioned above in some detail.

HIGH ENERGY AND NUCLEAR PHYSICS

The High Energy and Nuclear Physics programs seek the answers to questions that man has asked for many hundreds of years, namely, what are the basic constituents of matter and what forces govern them. Twenty-five hundred years ago, Aristotle believed that the basic constituents of matter were earth, fire, air and water. It was not until the early 17th century that true experimental study began; and only at the beginning of the 20th century did the field of particle physics take shape as scientists began to understand that the atom was not a fundamental particle but was composed of a nucleus and electrons.

In the 1930's, the field of nuclear physics grew as physicists learned that the nucleus is composed of even smaller constituents (protons and neutrons). As scientists gained a deeper understanding of the nucleus in the mid-1950's, they began to realize that an even more fundamental level of matter must exist. In the last 25 years, remarkable progress has been made in high energy physics, the field that focuses on discovering and understanding the fundamental constituents of matter and the forces of nature that govern them.

The High Energy and Nuclear Physics programs have made significant contributions not only to energy resource development, but to education, health, industry and national defense. Contributions to the economic growth and prosperity of the Nation have come directly from the results of the research, from technological spinoffs and from the training of tomorrow's scientists through participation of university graduate students in carrying out the research. Through technology transfer, these ideas and people have made contributions in a variety of industries including medical instrumentation, control and instrumentation of industrial processes, the production of nuclear energy, and many applications of electronic and computer techniques.

The High Energy and Nuclear Physics programs are closely related not only in terms of overall goals, but also in the types of facilities and equipment used to reach these goals and the impact that research in one program has on the other. Both seek to contribute to an understanding of the basic constituents of matter and the forces that govern them. Nuclear Physics does so by studying the nucleus; High Energy Physics does so by studying the most fundamental of particles that comprise the nucleus and all other matter.

Experiments in both the High Energy and Nuclear Physics programs depend on large experimental facilities that accelerate beams of particles to collide with stationary targets or head-on with other moving particle beams. Studying the results of these collisions helps scientists to learn about the properties of the underlying building blocks and basic forces involved. Although research progress depends on the availability of these forefront accelerator and colliding beam facilities, as well as on the detectors that record the results of the collisions, progress also depends on a continuing interplay of advancements in experiment, theory and technology. Often the range of experiments possible is determined by available technology; and physicists frequently have to invent new equipment and technology to carry out the most important experiments.

In the High Energy Physics program, research utilizing accelerators is conducted principally at four major accelerator laboratories in the U.S., two in Europe and one in Japan and encompasses more than 150 user groups. The Nuclear Physics program, carried out at seven national facilities, accommodates approximately 70 user groups. The program also utilizes facilities in Canada and Europe. Participants from over 100 universities across the country and from more than 50 foreign institutions contribute to the success of the High Energy and Nuclear Physics programs.

HIGH ENERGY PHYSICS

Progress toward improving our understanding of energy and matter and their most elemental transformations has come rapidly in recent years. In developing this knowledge, five U.S.-supported high energy physicists have won or shared in Nobel prizes during the last six years. The major current objective of high energy physics research is unification of the basic forces into a single theoretical framework; in other words, a single theory that would describe all of the interactions of matter and energy existing in the universe.

The ultimate goal is to link together, or unify, the four known forces of nature. The electromagnetic force describes how atoms and molecules are formed and is the cornerstone to understanding chemistry, electronic communications and biological processes. The weak nuclear force describes processes such as the radioactive decay of nuclei. The strong nuclear force helps describe how the sun and the stars produce so much energy. Together with the weak nuclear force, it also describes the relative abundance of the chemical elements. The gravitational force, perhaps the most familiar of the forces of nature, explains such things as how objects fall and planets move in their orbits.

Results of high energy physics research have led to an increasingly better understanding of the forces of nature and the unifying connections among them. A part of the recent progress in high energy physics has been the conceptual unification of the weak nuclear and electromagnetic forces into a single "electroweak" framework. There is increasing anticipation that the unification of the strong nuclear and electroweak forces into one "grand unified" framework may be possible, thus reducing the apparent number of forces in nature to two. The ultimate goal is to determine whether the gravitational force can be incorporated into a "super-grand" unification that would bring all of the forces in nature into a single unified framework.

Before I discuss the budget request, I would like to report on some of the recent accomplishments in the High Energy Physics program. The Energy Saver, the world's first high energy accelerator using superconducting magnets, has been brought into successful operation at Fermi National Accelerator Laboratory (Fermilab). In February 1984 the accelerator began providing beam for the first round of experiments with protons at energies up to 800 billion electron volts (GeV). In the Summer of 1985 the accelerator will be generating antiproton beams for colliding beam tests. In FY 1985 the accelerator is expected to operate at energies near 1000 GeV.

Last July the Alternating Gradient Synchrotron at Brookhaven National Laboratory (BNL) produced the world's highest energy beam of polarized protons. Forty percent of the protons in the beam were produced with spins aligned in one direction. With this capability, scientists have begun important studies of spin effects in reactions that have baffled theorists since 1977.

Successful development of the Stanford Linear Collider at the Stanford Linear Accelerator Center (SLAC) will provide an essential demonstration of the technical feasibility of the new linear collider concept, which is a critical step toward future cost-effective extensions of electron-positron reaction energies beyond the maximum energy practical with circular accelerators. Important successes in the development of specialized technical components for this construction project have been achieved in the last year. These include successful commissioning of the first of two small storage rings, called damping rings, which are needed to reduce the size of the electron and positron beams, and the development of a new microwave power accelerating tube, a klystron capable of delivering 50 million watts of peak power for beam acceleration.

Some recent scientific achievements in high energy physics include the following. Discovery of the W^+, W^- and Z^0 particles which carry the electroweak force was accomplished by the UA-1 collaboration (including Harvard, University of California at Riverside, and Wisconsin) at the European Organization for Nuclear Research (CERN). Two European physicists, Carlo Rubbia (of Harvard and CERN) and Simon Van der Meer (CERN), shared the 1984 Nobel Prize in Physics for their part in this discovery. New modes of decay of the W and Z particles have also been discovered. In addition, candidate events for the sixth of the fundamental constituents of matter called quarks--the "top" quark--have been identified in experiments also by the UA-1 collaboration.

Several university and laboratory groups in the U.S. and Europe have been calculating the masses of the lightest strongly interacting particles from the first principles of quantum chromodynamics, the fundamental theory which describes the strong nuclear force. The availability of supercomputers has made these calculations possible.

FY 1986 HIGH ENERGY PHYSICS BUDGET REQUEST

The FY 1986 request for the High Energy Physics program is $510.1 million, which consists of $391.5 million for Operating Expenses, $63.1 million for Capital Equipment and $55.5 million for Construction (Table 2).

A major part of the funding for the program is required to meet the direct needs of the accelerator laboratories to develop, maintain and operate the major accelerator, colliding beam and detector facilities. In FY 1986, the accelerator and colliding beam facilities include: the 30 GeV proton synchrotron, called the Alternating Gradient Synchrotron, at BNL; the 1000 GeV superconducting magnet proton synchrotron at Fermilab; and the 32 GeV linear electron accelerator at the SLAC. SLAC also has two electron-positron colliding beam facilities for which the linear accelerator acts as the injector: the Stanford Positron Electron Asymmetric Ring (4 GeV x 4 GeV) and the Positron-Electron Project (15 GeV x 15 GeV). The facilities at these

Table 2
High Energy Physics
Budget Authority
($ in millions)

	FY 1985 Estimate	FY 1986 Request
Operating Expenses		
Physics Research	$107.5	$111.3
Facility Operations	175.2	187.8
High Energy Technology	90.2	92.4
Subtotal	$372.9	$391.5
Capital Equipment	58.7	63.1
Construction	114.0	55.5
Total High Energy Physics	$545.6	$510.1

laboratories provide the source of experimental data for most of the High Energy Physics research, more than 75% of which is carried out by university-based scientists. The overall utilization level of the accelerator facilities in FY 1986 will be in the 45-50 percent range.

The FY 1986 Operating Expenses request is $391.5 million. A major feature of the program will be the operation of the Tevatron superconducting synchrotron at Fermilab in the 800-1000 GeV energy range. Operation at this level for fixed-target experiments was made possible by upgrading experimental areas and beam lines external to the main ring. Also in FY 1986, pre-operating tests of the proton-antiproton colliding beam capability provided by Tevatron I will be carried out.

The program also will include operation of and research at the Alternating Gradient Synchrotron at BNL with its new, unique high energy polarized proton beam and, at SLAC, operation of the Positron Electron Project and pre-operating systems tests of the Stanford Linear Collider. The FY 1986 budget request also includes funding to continue advanced technology R&D.

Part of this effort is the continuation of research and development on the large accelerator collider called the Superconducting Super Collider (SSC), for which the FY 1986 budget request includes $20 million. It is envisioned as a proton-proton collider with an energy of 20 trillion electron volts per beam. If built, the SSC would provide a research capability in an unexplored domain for which there are no existing or planned facilities anywhere in the world and in which there is strong expectation of major research breakthroughs. In FY 1986, SSC-related R&D continues with emphasis on advanced accelerator R&D to develop a cost/performance optimized design for the selected superconducting magnet type, as well as cost-effective techniques for fabricating the superconducting magnets.

The FY 1986 Capital Equipment request of $63.1 million provides a small increase above the FY 1985 level to help meet the highest priority needs associated with the initial complement of detectors and secondary beams being provided by the Tevatron projects at Fermilab and by the Stanford Linear Collider at SLAC. These initial detectors and beams account for $30.6 million of the total Capital Equipment request. The total Equipment request for FY 1986 is essential for effective use of existing facilities and the new facilities being completed in FY 1985 and 1986 at Fermilab and SLAC.

The FY 1986 Construction request is $55.5 million. The projects are listed in Table 3. A major portion of this request is for completing the construction of the Stanford Linear Collider at SLAC. The primary goal of this project is to develop and demonstrate the technical feasibility of using linear accelerators with precisely controlled, high intensity and highly focused beam pulses to provide high rates of

Table 3
High Energy Physics
Budget Authority
($ in millions)

Construction	FY 1986 Request	TEC	Completion Date
Tevatron I (81-E-218)	$ 8.6	$ 84.0	FY 1986
Stanford Linear Collider (84-ER-133)	22.9	115.4	FY 1986
Central Computing Upgrade, Fermilab (86-R-104)	3.1	23.9	FY 1988
Accelerator Improvements and Modifications Project (86-R-102)	10.5	10.5	FY 1988
General Plant Projects (86-R-103)	10.4	10.4	FY 1988
Total Construction	$ 55.5		

electron-positron collisions at energies far beyond those that will be affordable for circular colliders. It also will provide early access to the important physics regime in which Z^o particles are copiously produced. The Z^o particles are one of a family of particles that carry the electroweak force. In addition, the request provides for completion of the Tevatron I project at Fermilab. Tevatron I will be the highest energy collider in the world. The Construction request also provides for upgrading of the central computing capability at Fermilab. This upgraded computing capability at Fermilab is essential for effective analysis of the large volume of new physics data coming from the Tevatron program.

Funds are requested for Accelerator Improvement and Modifications Projects ($10.5 million) that are critical on an annual basis to maintain the scientific effectiveness and the operating reliability and efficiency of the accelerator and colliding beam facilities. The request also provides $10.4 million for General Plant Projects (GPP) which are required to keep the general plant of the laboratories (e.g., buildings, roads, utilities) in operating condition.

NUCLEAR PHYSICS

The Nuclear Physics program is a comprehensive program of interdependent experimental and theoretical investigations of atomic nuclei. The goal of the program is to understand the interactions, properties and structures of atomic nuclei and nuclear matter at an elementary level and, as a complement to high energy physics research, to learn about the fundamental forces of nature by using nuclei as a proving ground.

The behavior of nuclei and nuclear matter determine the physical properties of our universe--from its creation as a primordial mix of energy and elementary particles, to the reactions that power our sun and the particles and forces that make up our planet. An understanding of nuclei and nuclear phenomena is essential to any basic understanding of the world around us.

In terms of trained researchers, new knowledge, and advanced instrumentation, the Nuclear Physics program is a central component in the Nation's long-term investment in its technological future. Nuclear knowledge, techniques, instruments and applications have become an integral part of American society. They serve as the basis for our national defense, for therapeutic and diagnostic medical applications, for generation of electricity with nuclear reactors and for a large and diverse array of applications in the commercial sector.

Based on recent research results, nuclear physicists are optimistic that a new level of understanding of atomic nuclei is achievable. This optimism stems from evidence that the mesons, protons and neutrons that are inside nuclei are themselves composed of yet smaller particles called quarks and gluons. It is also based on the likelihood that the theory called quantum chromodynamics can be developed into a theory that correctly describes the interaction between quarks and gluons and is also an exact theory of the strong nuclear force.

Before turning to the budget request, let me summarize several Nuclear Physics accomplishments achieved during the past year. By colliding high energy, heavy nuclei with stationary nuclei in the laboratory, scientists working at Lawrence Berkeley Laboratory's Bevalac accelerator have created nuclear matter at temperatures and pressures not previously seen. In these collisions, nuclear matter was compressed to several times normal density and was actually observed to flow like a liquid.

For the first time, the elastic scattering of electron-type neutrinos from electrons has been observed. Scientists used the beam stop at the Clinton P. Anderson Meson Physics Facility (LAMPF) as an intense source of electron-type neutrinos. During the first run of the experiment, 16 billion billion neutrinos passed through the apparatus and 20 events were detected. This work is an important test of our understanding of the "electroweak" force.

The Argonne Tandem/Linac Accelerator System (ATLAS) construction project is on schedule and within estimated cost. All eighteen superconducting resonators for the ATLAS project have been successfully tested and installed. First beam through the entire ATLAS accelerator complex is scheduled for April 1985 with initial experiments planned for May.

The FY 1986 Nuclear Physics program will emphasize continued experimental investigation of the behavior of quarks inside nuclei and of the way in which quarks determine the makeup and properties of nuclei. In nuclear theory, emphasis in FY 1986 will be on understanding the limitations of the present quantum chromodynamics theories as exact theories of the nuclear force, on improving these theories, and on understanding the ways in which new quark configurations would become evident.

FY 1986 NUCLEAR PHYSICS BUDGET REQUEST

The FY 1986 budget request for the Nuclear Physics program is $172.9 million. Of that amount, $151.9 million is for Operating Expenses; $14.0 million is for Capital Equipment; and $7.0 million is for Construction (Table 4). Almost half of the Operating Expenses request ($81.3 million) is needed for operation of accelerator facilities. In FY 1986, the national facilities are expected to achieve an overall utilization rate of 45 percent.

As is the case with High Energy Physics, the Nuclear Physics program depends upon the operation of large and complicated accelerator facilities to provide a variety of projectile beams required for forefront nuclear research. The existing accelerator facilities are

Table 4
Nuclear Physics
Budget Authority
($ in millions)

	FY 1985 Estimate	FY 1986 Request
Operating Expenses		
Medium Energy Nuclear Physics	$ 74.6[a]	$ 76.5
Heavy Ion Nuclear Physics	49.4	52.6
Low Energy Nuclear Physics	13.5	13.4
Nuclear Theory	9.3	9.4
Subtotal	146.8	$151.9
Capital Equipment	12.7	14.0
Construction	23.3	7.0
Total Nuclear Physics	$182.8	$172.9

[a] Includes $3.1 million which was provided by Defense Programs for LAMPF facility operations.

supported by the Nuclear Physics program as national facilities whose beam time is made available to all the Nation's scientists on the basis of the scientific merit and technical feasibility of proposed research projects. The national facilities are: the Clinton P. Anderson Meson Physics Facility at Los Alamos National Laboratory (LANL); the Bates Linear Accelerator Center at the Massachusetts Institute of Technology (MIT); the SuperHILAC/Bevalac at Lawrence Berkeley Laboratory (LBL); the Argonne Tandem/Linac Accelerator System (ATLAS); the Holifield Heavy Ion Research Facility at Oak Ridge National Laboratory (ORNL); the 88-inch Cyclotron at LBL; and the Double MP Tandem Van de Graaff facility at Brookhaven National Laboratory (BNL). To complement these national facilities, the Nuclear Physics program also supports on-campus accelerators at several universities: Yale, Duke, the University of Washington and Texas A&M.

The FY 1986 Nuclear Physics budget request includes funds for initial heavy ion nuclear research and accelerator operations at the Alternating Gradient Synchrotron (AGS) at BNL. Upon completion in FY 1986, the Tandem/AGS Heavy Ion Transfer Line will provide heavy ion beams to the AGS for acceleration to energies and masses not possible anywhere else in the world. This unique capability offers the possibility that scientists may be able to create exotic new states of nuclear matter never before observed in the laboratory.

Another major feature of the FY 1986 Nuclear Physics program is the continuation of R&D and architect and engineering activities to better define the Continuous Electron Beam Accelerator Facility (CEBAF) project's scope, schedule and total cost. In FY 1986, $5.0 million in Operating Expenses are requested for this purpose. This work is aimed at establishing a technical base so that construction could be initiated in FY 1987.

CEBAF is projected to be a major facility centering on an electron linear accelerator/stretcher ring complex capable of delivering intense, continuous beams in the energy range from 0.5 to 4 billion electron volts. Ultimately, CEBAF would have the capability of addressing a crucial class of investigations facing nuclear physics today, namely, understanding the relationship between the traditional and emerging descriptions of nuclear dynamics. More specifically, CEBAF would provide unique research opportunities to U.S. scientists and, through international collaboration, to scientists from abroad. CEBAF would make it possible for these scientists to investigate the ways in which quarks that are bound in neutrons and protons influence the makeup and behavior of nuclei. They would also be able to study how quarks interact while embedded within nuclear matter and to test quantum chromodynamics as the fundamental theory of the strong nuclear force.

The Capital Equipment request of $14.0 million would provide for particle detection systems, data acquisition and analysis systems, and instrumentation to improve the performance of Nuclear Physics accelerators. These funds are essential for the effective operation of the national accelerator facilities supported by the Nuclear Physics program. Of the total request, $13.2 million are required for projects at BNL, LBL, ORNL, Argonne National Laboratory, the Clinton P. Anderson Meson Physics Facility at LANL, Bates Linear Accelerator Center at MIT, Oak Ridge Associated Universities and Duke University. Since the Nuclear Physics program is responsible for providing all of the general purpose equipment at LBL, the remaining $.8 million is for that purpose.

The FY 1986 Construction request of $7.0 million (Table 5) is for Accelerator Improvements and Modifications Projects ($3.5 million) and for General Plant Projects ($3.5 million). These projects are needed to maintain the scientific effectiveness, reliability and efficiency of Nuclear Physics facilities.

GENERAL SCIENCE PROGRAM DIRECTION

The FY 1986 budget request for General Science Program Direction is $2.4 million. These funds are required to provide for the salaries, benefits, travel and other expenses associated with 39 full-time equivalents in the Office of the Associate Director for High Energy and Nuclear Physics and associated support staff required to administer these programs.

Now let me turn to the Basic Energy Sciences program.

Table 5
Nuclear Physics
Budget Authority
($ in millions)

Construction	FY 1986 Request	TEC	Completion Date
Accelerator Improvements and Modifications Projects (86-R-204)	3.5	3.5	FY 1988
General Plant Projects (86-R-205)	3.5	3.5	FY 1988
Total Construction	7.0		

BASIC ENERGY SCIENCES

The goal of the Basic Energy Sciences (BES) program is to develop basic scientific and engineering knowledge that can be used by the Government and the private sector to develop new concepts, products, materials and processes. Although the principal focus of the BES program relates to energy development and use, a number of other important national goals are also supported. U.S. leadership in science and technology, economic growth, and training for tomorrow's scientists are all beneficiaries of properly conceived programs of basic research. While contributions from basic research cannot always be identified immediately or directly, the knowledge that flows from this research forms the foundation on which new ideas and concepts can build in each of these areas.

The BES program annually supports approximately 1200 individual research projects in the physical, biological and mathematical sciences. These projects are selected on the basis of scientific excellence, relevance to BES' long-term goals, and their contribution toward a balanced research program. This research is carried out largely by scientists at universities and national laboratories across the country.

An important benefit that results from supporting university researchers is the technology transfer that occurs when graduate students carry their new knowledge into the private sector after completing their studies. In addition to universities and laboratories, BES also maintains ties with industry through a variety of mechanisms. These include participation in workshops and the use by industry of the specialized research facilities supported by BES.

During the past year, BES research was conducted in seven areas: materials sciences; chemical sciences; nuclear sciences; mathematical sciences; engineering and geosciences; biological sciences; and advanced energy projects. The impact of research results from over 1200 projects cannot easily be conveyed, not only because of their volume, but also because their ultimate importance may not be evident at first. The following recent examples of research results do, however, provide insight into the diversity and scope of the BES program.

These accomplishments include:

o Development of a new high-temperature, oxidation-resistant material (nickel aluminide) that can be produced by conventional methods and is better than existing super alloys for use where long-term, high-temperature service is required, such as in heat engines. The potential of this aluminide has already been recognized by an IR-100 award as well as industrial interest in producing this material.

o Development of a novel processing method that permits machining of materials to a dimension 1000 times smaller than can be accomplished commercially today. One potential application of this method is the development of computer memories with storage densities one million times greater than is presently possible. New applications, such as the one just cited, will require new manufacturing concepts rather than refinement of current ones.

- Discovery of a new catalytic system for the direct conversion of carbon monoxide and water to methanol. This new catalyst makes it possible to make the conversion using water rather than the more expensive hydrogen and at pressures and temperatures much lower than current practice allows.
- Development of improved solid state electronic devices to operate at higher temperatures, thus paving the way to important advances in measurement methods and process control in hostile environments.
- Demonstration of a new source of electromagnetic radiation, known as the free electron laser, at conversion efficiencies and power levels which make the laser a candidate source for numerous applications, including extremely powerful accelerators.

While it is not possible to say which of the above research accomplishments might have major strategic or economic importance in the future, it is important to realize that today's high technology industry is based on similar research carried out in the past.

To illustrate my point, some 25 years ago the materials program supported the initial research on metallic glasses. These glassy metals have an atomic structure that is different from the metals with which we are familiar. We now know that metallic glasses are useful in magnetic applications because they can be magnetized and demagnetized with less energy loss than can ordinary structured metals. We also know that they are potentially the strongest, most corrosion-resistant material known and that they are economical to manufacture because the production process uses less energy than consumed by conventional processes.

As a result of that original research and subsequent basic and developmental research done by industry and universities, glassy metals have made a significant impact in the commercial areas of communication and lighting; for example, they are being used in the recording and playback heads of tape recorders and in the starting circuits in fluorescent lights. Research in the private sector continues on production techniques for glassy metals. One potential additional use might be the substitution of glassy metals for steel in electric power transformers. Losses in magnetic energy in these transformers amount to more than $600 million a year, most of which might be saved with the use of glassy metals.

As is illustrated by this example, the results of basic research can take as long as 10 to 20 years before there are commercial applications. Thus, I believe that it is fair to say that the funding for research in the basic sciences can be considered crucial for technological progress in the future.

This kind of research progress is made possible, in part, by the large state-of-the-art facilities that are supported by the BES program. These facilities are not only an integral part of the program; they also serve the scientific community. Industry, university, and government researchers have access to these facilities for promising research projects. These facilities are available at no cost to the user if the project is of high technical merit, is of interest to DOE and cannot be carried out without access to the facility. In addition, the significant results are published and made available to the R&D community. If the research requires the use of the facility but is of a proprietary nature, a user fee is charged. This combination of laboratory, university and industry researchers working side by side is extremely beneficial. The government gains when researchers supported by our program interact with their counterparts in the private sector. We also benefit from the trained scientists and unique instrumentation and equipment that are provided at no cost to the Department by the companies that conduct research at our facilities. Both industry and the university communities gain by having access to some of the most advanced facilities in the world.

Several state-of-the-art facilities are in operation. Each promises to open whole new areas of research opportunities. These facilities include: the National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory; the Intense Pulsed Neutron Source (IPNS) at Argonne National Laboratory; the 1.5 MeV High Voltage Electron

Microscope and the Atomic Resolution Microscope (ARM) located at Lawrence Berkeley Laboratory's National Center for Electron Microscopy; and the Combustion Research Facility (CRF) at Sandia Livermore. A list of BES user facilities is contained in Table 6.

FISCAL YEAR 1986 BASIC ENERGY SCIENCES BUDGET REQUEST

The FY 1986 budget request for the BES program is $409.8 million, which consists of $343.2 million in Operating Expenses, $30.5 million in Capital Equipment and $36.1 million in Construction funds (Table 7). This request supports the core program for each of the research areas at the FY 1985 level, with modest increases in the materials and nuclear sciences areas for major user facility operations. The requested Operating Expenses increase of $5.4 million in Materials Sciences and $3.0 million in Nuclear Sciences will cover increased costs related to power, fuel, and essential operating personnel, as well as safeguards and safety requirements.

Of the total FY 1986 Operating Expenses request of $343.2 million, approximately 30% will be spent to operate and carry out research at the major BES facilities. As I noted earlier, these facilities are used not only by the Department, but also by other Federal agencies, by industry and by university researchers. They represent an

Table 6
Basic Energy Sciences Facilities

High Flux Beam Reactor (HFBR) - Brookhaven National Laboratory

National Synchrotron Light Source (NSLS) - Brookhaven National Laboratory

Intense Pulsed Neutron Source (IPNS) - Argonne National Laboratory

High Voltage Electron Microscope-Tandem Facility - Argonne National Laboratory

Oak Ridge Electron Linear Accelerator (ORELA) - Oak Ridge National Laboratory

High Flux Isotope Reactor (HFIR) - Oak Ridge National Laboratory

Combustion Research Facility (CRF) - Sandia National Laboratories, Livermore

National Center for Electron Microscopy - Lawrence Berkeley National Laboratory

Stanford Synchrotron Radiation Laboratory (SSRL) - Stanford University

Spallation Neutron Research Facility (SNR) - Los Alamos National Laboratory

Table 7
Basic Energy Sciences
Budget Authority
($ in millions)

	FY 1985 Estimate	FY 1986 Request
Operating Expenses		
Materials Sciences	$133.0	$138.5
Chemical Sciences	79.5	79.5
Nuclear Sciences	40.3	43.3
Applied Mathematical Sciences	35.1	28.0
Engineering and Geosciences	26.7	26.7
Advanced Energy Projects	10.6	10.6
Biological Energy Research	12.5	12.5
Program Direction	3.8	4.1
Subtotal	$341.5	$343.2
Capital Equipment	31.1	30.5
Construction	50.0	36.1
Total Basic Energy Sciences	$422.6	$409.8

investment in the Nation's long-term research and technological future. The budget request will ensure continued operation and access to these facilities in FY 1986.

The FY 1986 budget also would continue support for promising research that we believe will have a significant impact on energy. Three items in the request exemplify the type and diversity of research with such potential. These are advanced materials research; combustion research; and enhanced computational research and computer access. Let me first discuss advanced materials research.

The FY 1986 budget request will continue support for the materials initiative that began in FY 1984. That activity currently consists of a Center for Advanced Materials at Lawrence Berkeley Laboratory (LBL), improvements at the Stanford Synchrotron Radiation Laboratory and expanded activities at Brookhaven National Laboratory's (BNL) National Synchrotron Light Source. The health and national security of the U.S. requires that we maintain a commanding lead in high technology and reduce U.S. vulnerability to critical and strategic imported materials. The ongoing advanced materials research activity is being organized to provide maximum benefit to the Nation. Industry will participate in the design of the research program to assure that it addresses America's high technology needs.

The focus of this effort is on advancing the technical base of information in materials sciences. With the expansion of access and capability at the three sites, the number and diversity of researchers who are able to do collaborative research will be greatly enhanced. Interactions among laboratory, government, industry, and university researchers also will be increased at these sites. We expect that the result will be significant advances in materials theory and applications.

The second area with great research potential that I would like to discuss is combustion. The combustion process is one of the most important processes involved in producing the Nation's energy. The potential exists for significant savings in both fuel usage and cost if the efficiency of the combustion process can be improved. Combustion is an extremely complicated series of chemical events that involve a large number of chemical forms, or species, that exist during various stages of the combustion process. Although many of these species are short lived and present only in minute quantities, they are critical to the combustion process.

Long-term basic combustion research requires state-of-the-art techniques to detect these chemical species, obtain basic data on the chemical reactions that occur and create theoretical concepts and computational methods that can be used to understand combustion dynamics. Scientists supported by the BES Chemical Sciences program are carrying out research in all of these areas. The research is being conducted at universities and national laboratories, with the focus at the Department's Combustion Research Facility at Sandia Livermore. The goal is to make combustion chemistry predictable and, thus, of direct use to present and future engineers in the design and development of more efficient combustion systems.

The third research activity I would like to highlight is in our Applied Mathematical Sciences subprogram. Supercomputers are playing an increasingly important role in many of the Department of Energy's (DOE) programs. Every generation of large scientific computers has had a significant positive impact on the ability of the DOE laboratories to meet their mission goals. Each new machine has improved the laboratories' abilities to model more accurately complex physical phenomena, thus improving their productive capability and reducing the number of expensive tests now required.

This improved capability has been recognized, for example, in the design and testing of nuclear weapons and in magnetic fusion research. In FY 1983, DOE programs in the fundamental sciences began to use supercomputers as "experimental" devices for theoretical calculations. Large-scale scientific computers are needed for research in high energy physics, condensed matter research, and chemical and biological theory, among others. Calculations of subatomic particle confinement, critical phenomena in alloy solidification and superconductors, thermophysical properties of chemical mixtures, and properties of long-chain polymers are providing insight into the basic properties of matter.

The Applied Mathematical Sciences subprogram consists of two activities: research and access. The goal of the research portion of the program is to advance our understanding of the fundamental concepts of mathematical modeling involved in the key physical processes being investigated in the Department's mission-oriented programs. Much of the scientific research and development effort throughout DOE is focused directly on analytical and numercial modeling of these physical processes. Basic research in the relationships among the mathematical formulation of scientific and engineering problems and the creation of algorithms for solving these problems on novel computer architectures can be expected to make a significant contribution to the development of future energy production and distribution systems.

The access part of the program is aimed at meeting the immediate needs for supercomputer access by the Department of Energy's High Energy and Nuclear Physics, Biological and Environmental Research, and Basic Energy Sciences programs. This access program will make a substantial contribution not only to solving the national problem of providing access to supercomputers for energy researchers, but also toward furthering research in the programs through the use of state-of-the-art computational tools and techniques. Additionally, this access program helps to ensure that the U.S. maintains its lead in the computational sciences related to supercomputer technology. We have recently brought on-line a class VI computer to provide supercomputer support for these programs and it was over 90 percent utilized within one month of installation, supporting over 1200 energy researchers at over 60 geographically dispersed locations.

The Capital Equipment request for FY 1986 is $30.5 million. This level of funding is necessary to meet ongoing research requirements, additional commitments associated with the newer facilities and additional equipment for selected areas of promising research. Examples of equipment to be purchased include high resolution nuclear magnetic resonance equipment, computer peripherals (e.g., disk and tape units), a fluid chromatograph for use in analyzing chemical solutions, infrared spectrometers, chemical vapor deposition apparatus, and an x-ray microprobe analyzer.

The requested funding will assure that researchers involved in our program continue to have the modern, sophisticated equipment needed to conduct advanced research.

Table 8 details the Construction request for FY 1986. Three of the projects, as mentioned earlier, are associated with the enhanced materials effort which began in FY 1984: the Center for Advanced Materials (CAM) at LBL, the Stanford Synchrotron Radiation Laboratory (SSRL), and the National Synchrotron Light Source (NSLS) at BNL. The CAM project consists of two buildings: A Surface Science and Catalysis Laboratory which will provide state-of-the-art instrumentation and facilities; and the Advanced Materials Laboratory

Table 8
Basic Energy Sciences
Construction Summary
Budget Authority
($ in millions)

	FY 1986 Request	TEC	Completion Date
Kansas State University Ion Collision Physics Facility (85-ER-403)	1.9	5.1	FY 1988
Beam Lines and Support Area Construction (84-ER-111)	7.2	19.7	FY 1987
Center for Advanced Materials (84-ER-112)	17.4	40.3	FY 1988
Stanford Synchrotron Radiation Laboratory Enhancement (84-ER-113)	2.6	12.9	FY 1986
Accelerator Improvements and Modifications Projects (86-R-401)	$ 3.0	$ 3.0	FY 1987
General Plant Projects (86-R-400)	4.0	4.0	FY 1987
Total	$36.1		

which will be devoted to interdisciplinary study of the synthesis and characterization of energy-related high technology and strategic materials. Both of these facilities will be based on strong programs that exist at the Lawrence Berkeley Laboratory. The FY 1986 budget includes $17.4 million for this project.

At NSLS $7.2 million is requested in FY 1986. This funding continues the project and will meet the demands for a much higher level usage. Additional experimental equipment and space will be provided. When fully instrumented, the NSLS facility will be able to accommodate 90 experiments simultaneously.

For the SSRL, the FY 1986 request is $2.6 million to complete the project. This funding will allow us to continue construction of three principal items: the construction of two conventional beam lines, and three special beam line facilities as well as the alteration of the electron storage ring. These improvements will ensure the usefulness of this facility for basic research for many years to come.

The other major project proposed for continued funding in FY 1986 is the Kansas State University Ion Collision Physics Facility; $1.9 million is requested for this project. This facility which is jointly funded by the University, will allow researchers to study the atomic physics of a range of ions unmatched in the world.

The remaining construction funds are requested for General Plant Projects and Accelerator Improvement and Modifications Projects. For these two construction items the FY 1986 request is $4.0 million and $3.0 million, respectively.

This completes my summary of the BES program. Now I would like to discuss the Biological and Environmental Research program.

BIOLOGICAL AND ENVIRONMENTAL RESEARCH PROGRAM

The goal of the Biological and Environmental Research (BER) program is to support long-term research aimed at providing the scientific data needed to anticipate, identify, and understand the long-term health and environmental consequences of energy use and development, including the health and safety of its personnel during research and development operations.

There is growing recognition that achievement of many of the Nation's goals will depend in large part on knowledge produced by a strong, broad national science capability--a capability to which the BER program contributes. The FY 1986 budget request would support a program of excellent basic and applied research that will continue to contribute to the Nation's economic growth and well-being.

The BER program melds fundamental research aimed at defining how normal biological systems operate with applied studies to characterize how such systems are affected by energy-related activities. The goal is to identify potential effects before they occur and determine their magnitude at a sufficiently early time so that problems can be eliminated or controlled. This helps to avoid the imposition of costly corrective measures, such as retrofits or operating restrictions, at a later date.

While the BER program represents the Department's and the Nation's only long-term research effort focused specifically on energy-related health and environmental issues, a number of other organizations complement these efforts. Both Department of Energy (DOE) technology programs and industry develop compliance-oriented data on the relatively near-term impacts of specific energy processses. Various Federal agencies, including the Environmental Protection Agency, the Nuclear Regulatory Commission and the National Institutes of Health also support limited research efforts on selected energy-related issues to meet their respective missions. Many interagency coordinating mechanisms are in place to provide forums for program planning and definition, research cooperation, and information exchange among these programs.

Another characteristic of the BER program is the extent to which other agencies and DOE programs rely on BER facilities and scientists to meet their research needs. This year other sponsors are providing over $100 million to DOE laboratories to address problems of national significance. This arrangement is productive, particularly in terms of the synergistic effects that benefit scientific productivity. While BER's unique instruments and facilities are made available to graduate and postdoctoral students as well as to experienced visiting researchers, it is also worth noting that nearly one-third of the BER research is conducted on academic campuses and hundreds of DOE-supported scientists hold academic appointments. This involvement with university students is an important contribution to the formal education of the Nation's future scientists.

Health and environmental concerns are associated with many of DOE's programs. Examples include issues that arise from the combustion of fossil fuels (e.g., acid rain and carbon dioxide) and from exposures to low levels of radiation or complex chemical mixtures such as those associated with many conventional and synthetic fuels. Reducing these health and environmental uncertainties is not a simple task. The majority of exposures about which we are concerned are exposures to low concentrations of energy-related substances over long periods of time, that is, over months or years. As a result, effects on humans and ecosystems are expected to be subtle and to occur long after the initial exposure. In addition, the health and environmental effects caused by chronic, low-level exposures often are not unlike those that occur spontaneously from natural causes or those that result from the action of toxic agents common to natural and man-made environments, such as sunlight, smoke and medical x-rays. Thus, it is difficult to determine or measure the health or environmental effects of chronic, low-level exposures against the "noisy" background of similar effects that can arise from other causes.

Complications like these make it necessary to use a variety of research approaches to predict the effects on humans and their environment of such low-level exposures to energy-related substances. Among these approaches is the determination of dose-effect relationships in humans at relatively high levels of radiation. From these observations, together with insights gained from animal, plant and cell-level experimentation, researchers can extrapolate to exposure levels where the effect is too small to be observable.

However, even this approach is inadequate when exposures reach extremely low levels as often happens in the real world. In these cases, the only way to estimate the degree of biological damage is by understanding the mechanisms that govern the production and repair of damage. It is in this field of research that the greatest progress is still to be made; and, consequently, BER's biological research will emphasize efforts aimed at understanding the fundamental mechanisms of biological damage and repair.

For FY 1986, the BER program will continue to focus on understanding long-term health and environmental responses to acute and chronic exposures to radiation and energy-related chemicals. This effort includes investigation of how these agents are transported and transformed as they pass through the environment.

The program also will continue to pursue its second important goal, the development of new applications of nuclear science and technology to improve the diagnosis and treatment of human disease. By exploiting the Department's unique capability in high energy physics, radiation chemistry and isotope separation, the BER program has pioneered efforts that have shown that it is feasible to use a broad array of radioactive and stable isotopes, labeled pharmaceuticals and radiation sources in the diagnosis and treatment of human disease and in biomedical research.

FISCAL YEAR 1986 BIOLOGICAL AND ENVIRONMENTAL RESEARCH BUDGET REQUEST

The FY 1986 budget request for the BER program is $186.3 million. Within this request, $175.3 million is for Operating Expenses; $7.8 million is for Capital Equipment; and $3.2 million is for Construction (Table 9). Funding by research area is shown in Table 10.

The BER program supports four major research areas in an effort to learn more about the long-term, or late, effects of energy development and use on human health and the environment. To estimate potential effects, it is necessary to be able to determine the exposure received by humans or the environment. The Source and Dose Determination research area, with an FY 1986 Operating Expenses request of $15.5 million, will continue to support research to develop new instrumentation and techniques to measure human exposure to ionizing radiation and to energy-related chemicals. This activity also will continue to support research aimed at defining the physical and chemical nature of biologically-active agents associated with energy technologies.

Table 9
Biological and Environmental Research
Budget Authority
($ in millions)

	FY 1985 Estimate	FY 1986 Request
Operating Expenses	$179.6	$175.3
Capital Equipment	7.9	7.8
Construction	3.0	3.2
Total	$190.5	$186.3

Table 10
Biological and Environmental Research
Budget Authority
($ in millions)

	FY 1985 Estimate	FY 1986 Request
Late Effects on Health & Environment of Energy Development and Use		
Source and Dose Determination	$ 15.7	$ 15.5
Environmental Processes & Effects	32.9	31.8
Health Effects	64.1	62.1
Basic Biology	28.3	28.0
Nuclear Medicine	21.8	21.2
Carbon Dioxide Research	13.3	13.1
Program Direction	3.5	3.6
Facility Operations	10.9	11.0
Total	$190.5	$186.3

A recent advance is illustrative of the kinds of accomplishments produced by this research. By combining advances made by the communications industry in long distance fiber optics with those in fluorescence analytical techniques, a new method for chemical monitoring called remote fiber fluorimetry has been developed. The new technique enables measurements to be made in hostile or inaccessible environments such as highly radioactive locations, deep underground sites or near jet or rocket engines where normal sampling and analysis procedures are difficult and involve considerable hazard, expense, and delay. This technique has been used successfully to measure uranium in highly radioactive environments and a variety of toxic pollutants in the environment. It also has been used for in vivo clinical measurements. Other anticipated applications include monitoring of ground water contaminants and high-level waste disposal sites as well as for industrial process, product and waste stream monitors.

Taking advantage of the data generated by the Source and Dose Determination activity, the Environmental Processes and Effects research area focuses on the pathways and mechanisms by which a contaminant moves through the environment. With an FY 1986 budget request of $31.8 million in Operating Expenses, this activity includes research on the ways that energy-related substances move through and interact with atmospheric, marine, and terrestrial environments. The goal of this research is to contribute to our ability to determine the potential impact of these substances on humans and on the environment. It will continue to address uncertainties regarding acid rain and the processes controlling long-range transport and transformation of energy-related organic materials, atmospheric gases, and aerosols. It also will focus on the processes that move radionuclides and other energy-related materials through marine, freshwater and terrestrial systems and the ultimate fate of those materials in the environment. A program developed to study the mechanisms controlling the transport of materials in ground water will be enhanced.

Among the many research results achieved by scientists studying environmental processes and effects last year was a discovery that has significantly improved our understanding of how plants respond to stress. In experiments at Oak Ridge National Laboratory, researchers have found that the chemical ethylene decreases the rate of photosynthesis in a variety of agricultural and forest plants by directly affecting the physiology of their pores. The same effects occur whether the ethylene is discharged to the atmosphere from coal- and oil-fired power plants or from ethylene produced by plants under natural stress such as that produced by drought. If the correlation between plant stress, productivity, and ethylene exposure can be more broadly substantiated, this knowledge would provide an improved understanding of the effects of industrial emissions and how to control them.

The FY 1986 Operating Expenses request for the Health Effects research area is $62.1 million. Research supported by this activity is aimed at developing a sound data base for evaluating human health risks that may result from exposure to ionizing radiation and energy-related chemicals. Health Effects research will continue to support a family of interrelated studies of humans who are known to have been exposed to radiation, of animal species and of molecular and cellular systems. Using some of the techniques developed by research on Source and Dose Determination, this effort emphasizes research on late-occurring health effects, such as cancer and genetic effects, that may be associated with chronic, low-dose exposures. For example, research to determine the health effects from exposure to complex chemical mixtures will be supported. In this area, scientists are trying to learn more about the chemical and biological interactions that can modify the effects of toxic chemicals when they exist as components of complex mixtures.

An understanding of the effects of toxic chemicals contained in complex mixtures is particularly important because most human exposures to environmental chemicals involve such mixtures. As a result of recent research conducted in the Health Effects activity, scientists have learned that nontoxic substances can enhance or diminish the biological potency of known toxic compounds when they coexist in model energy-related complex chemical mixtures. Therefore, the commonly held assumption that the toxicities of individual components of complex mixtures are cumulative is not necessarily valid. Future research will attempt to establish the basic biological principles that govern interactions between toxic and nontoxic components of complex mixtures. Knowledge gained concerning underlying principles could make it possible to estimate or approximate the toxicity of complex mixtures from available data on chemical composition.

Research in Basic Biology, for which $28.0 million in Operating Expenses is requested in FY 1986, is aimed at developing a body of biological knowledge for use in defining and measuring the human health impacts of energy technologies. A solid base of information about living systems must be established before biological alterations caused by energy-related agents can be interpreted fully. Recent advances in molecular and cellular biology have created the basis for improved automated approaches for the study of genetic damage at the chromosomal level. These advances already are bringing increased statistical reliability to the measurement of chromosomal damage in human cells, and continued improvements in reliability are expected.

In FY 1986, support will continue to be provided for research on normal and abnormal cell functions, cell multiplication and differentiation and the complex factors that influence these important processes. Research in molecular biology will focus on the nature of the gene, its mechanisms of duplication, the arrangement of genes in chromosomes and how this arrangement affects the way genes are expressed and regulated. In closely related work, the different means by which genes in mammalian species can be damaged and repaired also will be investigated. Research in chemical physics and instrumentation will be continued to develop advanced systems for biological applications and to investigate the fundamental processes that govern energy migration along and across macromolecules.

Over the years, the Nuclear Medicine Applications research area, with an Operating Expenses request of $21.2 million, has provided information that has led to the widespread use of nuclear technology in modern clinical and laboratory medicine, opening avenues of diagnosis and treatment that otherwise would not have been available. Indeed, a substantial industry has been spawned by DOE-supported research in this area. The goal of this research is to establish the medical feasibility of new technologies, instruments, and isotopic eaterials. Once the feasibility of these new applications has been established, they are taken over by the private sector for manufacture and distribution for patient diagnosis and treatment, or by other research agencies or institutions to be used for the study of specific diseases. In view of recent innovations and breakthrough research in radiopharmaceutical development and imaging instrumentation, this record of contributions is expected to continue.

In FY 1986, Nuclear Medicine research will emphasize the development of imaging technology in the areas of positron-emission tomography and single-photon emission computer-assisted tomography. This technology allows us to conduct noninvasive studies of specific organ systems. It now appears feasible to improve the spatial resolution of both imaging systems. Such higher resolution is essential to support studies of the fine structure of organ systems and their related metabolic functions. Research will continue on new applications of nuclear magnetic resonance spectrometry to make it possible to study normal and abnormal physiology and pathology associated with human diseases. In FY 1986, studies will be initiated to investigate variations in fat/tissue metabolism. Improved understanding of the *in vivo* regulation of fat/tissue metabolism offers promise of significant improvements in the diagnosis and treatment of human obesity, diabetes, and heart disease.

This research effort will build on a strong base program covering the development of new, medically-useful radioisotopes and radiopharmaceutical agents, improved instrumentation, and demonstration of the clinical feasibility of these techniques for the diagnosis and treatment of diseases and for the study of normal functions. Increasing emphasis will be given to the development and use of new techniques for analysis of function in health and disease.

The increasing use of radioisotopes to provide improved understanding of the metabolic processes in the brain and heart is especially significant. In a recent example of continuing progress in this area, researchers at Brookhaven National Laboratory used a combination of radioisotopes to demonstrate a substantial difference between the metabolism of fatty acids (the heart's principal fuel) by the heart muscle of healthy and hypertensive rodents. Similar metabolic differences have been observed by researchers at UCLA in patients with heart disease caused by reduced blood supply. By suggesting a new potential indicator of heart disease, these observations may be the basis for improved methods for detecting and treating previously unsuspected heart disease.

The Carbon Dioxide Research FY 1986 Operating Expenses request is \$13.1 million. Its goal is to develop a sound, quantitative atmospheric carbon dioxide knowledge base to aid in energy policy decision making. To do this, we must learn more about the carbon cycle and its direct effects on the climate. In addition, we must improve our ability to estimate future levels of carbon dioxide in the atmosphere and to detect a climate change based on those levels.

In FY 1986, activities will include maintaining the data base on CO_2 emissions and effects and carrying out a number of projects aimed at analyzing the direct effects of CO_2 on climate, vegetation, water resources and human health. These activities will continue and will include research into other trace (greenhouse) gases, such as methane, that act similarly to CO_2 in the way they affect the return of radiation to space. These trace gases may have an effect ranging from half to equal that of CO_2's effect on the climate. During FY 1986 considerable effort will be applied to refining and redefining program needs for the next decade based on the State-of-the-Art reports and Statement of Finding report to be published in FY 1985.

The FY 1986 budget request for Facility Operations is \$11.0 million. These funds provide for necessary capital equipment and construction needs to support the BER program and the Pacific Northwest Laboratory landlord responsibilities. The national laboratories and other onsite specialized laboratories supported by the BER program represent a national resource of skilled investigators of many disciplines, advanced scientific instrumentation and specialized research facilities. Our ability to address diverse health and environmental research issues requires a continued commitment to maintaining the advanced instrumentation and facilities of the laboratories.

The Capital Equipment request of $7.8 million for FY 1986 is essential for pursuing the health and environmental issues associated with energy technology considerations and for continued high quality research and advances in the development of nuclear medicine technology. Examples of such equipment needed at both universities and laboratories include spectrometers, chromatographs, scintillation counters and environmental chambers.

The Construction request for FY 1986 is $3.2 million. The request supports the program's General Plant Projects needs and the Pacific Northwest Laboratory landlord responsibility. A portion of these funds is needed for renovation of existing facilities for the use and care of experimental animals at Oak Ridge and Los Alamos National Laboratories. Without these renovations, important investigations using experimental animals to understand the biological effects of radiation and energy-related chemicals cannot be conducted in an acceptable manner.

The FY 1986 request for Program Direction is $3.6 million. These funds are required to provide for the personnel cost of 53 full-time equivalents to direct, manage and support these multidisciplinary research efforts.

This completes my summary of the BER program. I would now like to discuss the several ER outlay programs that are related to my statutory responsibilities to advise the Secretary on DOE energy R&D programs, the non-weapons multiprogram laboratories, and the education and training of scientists and engineers.

ADVISORY AND ASSESSMENT ACTIVITIES

Within the Office of Energy Research, the Office of Field Operations Management (FOM) and the Office of Program Analysis (OPA) support the Director's statutory advisory responsibilities. The Office of Field Operations Management provides support with regard to management oversight of the laboratories and energy-related manpower development and training activities of the Department. The Office has developed policies and several management tools that the Department uses to administer its laboratories and R&D facilities across the country. The office also manages the University Research Support, the University Research Instrumentation, and the Multiprogram Laboratories Facilities Support programs, each of which I will discuss shortly. The Energy Research Analysis program, managed by the Office of Program Analysis, on the other hand, provides independent and objective program analyses and technical assessments.

ENERGY RESEARCH ANALYSIS

The Energy Research Analysis (ERA) program is the only Departmental program specifically designed to provide independent technical assessments of DOE programs. One of the program's principal tasks is to solicit and obtain credible judgments by premier researchers and expert scientists of the quality of DOE-supported science and its eventual impact. Often following from these judgments are recommendations on the necessary next steps for the research. These recommendations provide independent views on future program directions for DOE program managers to consider. This method of technical review has evolved over the past 5 years with participation by several hundred industry, academic and laboratory researchers.

Recent accomplishments include a program assessment of research needs in the Office of Fossil Energy's Advanced Research and Technology Development program. This program accounts for about 20 percent of the total Fossil Energy FY 1985 budget. Several significant program direction changes resulted from this assessment of over 100 projects by 10 panels of experts.

In the area of technology assessments, a large number have been completed recently including: drilling for both oil and gas; photovoltaics; high-level radioactive waste; geothermal energy technology; solar thermal technologies; fuel cell research; and exploration of the continental crust through drilling.

In the area of acid rain, the Office of Program Analysis continues to represent DOE on the Interagency Task Force on Acid Precipitation. This Task Force plans, coordinates, assesses and establishes the budgets for all Federal acid rain research. A recent OPA-sponsored report by the JASON group identified a key scientific uncertainty in atmospheric chemistry: whether a reduction in emissions of SO_2 and NO_x would result in a like or much smaller proportional reduction in acid deposition on sensitive areas. The Energy Research Analysis program has been instrumental in bringing research to bear on this issue; and a National Laboratory Consortium mandated by the Energy Security Act of 1980 (P.L. 96-294) composed of four national laboratories (Brookhaven, Argonne, Pacific Northwest and Oak Ridge) will be heavily involved by FY 1986 in a comprehensive multi-year research effort to resolve this question.

The FY 1986 budget request for the Energy Research Analysis program is $2.7 million. It provides for: (1) one to two independent analyses of DOE R&D programs to evaluate technical merit and future directions; (2) two to three assessments of technologies; (3) support for assessment and coordination elements within the National Acid Precipitation Assessment Program, including support for the Interagency Acid Deposition Assessments Staff and DOE's share of the Program Coordination Office support; (4) support of groups such as the Energy Research Advisory Board (ERAB) and JASON; and (5) technical support on issue papers and alternative action studies, and international representation of United States Energy R&D future directions to the International Energy Agency (IEA).

UNIVERSITY RESEARCH SUPPORT

The goal of the University Research Support (URS) program is to help maintain strong scientific/technical research capabilities in support of the Department's long-range energy R&D mission in both the university community and the national laboratories. To accomplish this goal, the URS program provides a Departmental focus for several efforts which involve universities, both directly and in conjunction with the Department's national labs. The goals of these interrelated efforts are to:

- Maintain and strengthen university-based energy research and manpower development efforts in selected high priority energy research fields.
- Use the unique resources of the national labs (equipment, instrumentation and personnel) to assist in university faculty and student research and training.
- Increase the number and enhance the quality of students, including women and minorities, pursuing professional level degrees in energy-related science and engineering.
- Help strengthen the scientific/technical workforce in the Department's national labs.

With an FY 1986 budget request of $9.7 million in Operating Expenses, the URS program consists of two major subprograms (Table 11). The first of these is the University/National Laboratory Cooperative Research subprogram, with an FY 1986 Operating Expenses budget request of $8.7 million. This subprogram supports both University Laboratory Cooperative Research and University Reactor Fuel Assistance. One of the objectives of the Cooperative Research activity is to encourage the flow of bright, young research talent for future energy research programs by involving students in ongoing lab research programs. This approach offers the added benefit of making additional research capabilities available to participating university faculty. The second subprogram is Energy Manpower Development with an FY 1986 Operating Expenses request of $1.0 million. This subprogram combines two manpower-oriented activities. The Manpower Assessment activity conducts assessments and analyses of the supply and demand of manpower for both current and future energy R&D programs. The Energy Education and Training activity supports projects directed at encouraging secondary school students to pursue energy-related science and engineering programs at the college level.

The FY 1986 budget request for the URS program includes: (1) support for approximately 2200 student and faculty research participation appointments and special training appointments at the Department's labs and major contractors; (2) support for joint research and manpower development efforts with Historically Black Colleges and Universities and for 22 Prefreshman Engineering Program Projects that will reach over 2000 junior and senior high school students; (3) cost-shared support for 30 visiting industrial scientists through the joint

Table 11
University Research Support
Budget Authority
($ in millions)

	FY 1985 Estimate	FY 1986 Request
Operating Expenses		
Cooperative Research		
University Laboratory Cooperative Research	$ 6.5	$ 6.8
University Research Fuel Assistance	3.9	1.9
Subtotal	$10.4	$ 8.7
Energy Manpower Development		
Energy Manpower Assessment	0.5	0.5
Energy Education & Training	0.3	0.5
Subtotal	0.8	1.0
Total University Research Support	$11.2	$ 9.7

DOE National Laboratory-Industry Technology Exchange Research Program; (4) updated manpower assessments for future professional level manpower requirements (e.g., scientists and engineers) for DOE research programs; and (5) refueling of 6-7 university reactors and approximately 20 reactor sharing grants to be made on a competitive basis. This latter activity falls under the University Reactor Fuel Assistance program which provides fuel for university research and training reactors. The university-based nuclear research and manpower development effort is highly dependent on these specialized facilities not only for nuclear-related training but also for research in the basic sciences.

UNIVERSITY RESEARCH INSTRUMENTATION

Direct access to state-of-the-art scientific research instrumentation equipment is essential for continued progress in advanced, energy-related scientific and technical research. For example, frontier-level materials research in surface science and catalysis requires the ability to describe what is occurring at the atomic and molecular level. This research is essential for understanding such phenomena as carbon gasification, and the composition of surface gases.

Instruments used in this research must be able to detect and identify materials at the parts per billion level. Another example is in the field of biological energy research where a major limitation is in understanding the key proteins which influence physiological and genetic factors related to plant productivity. Advances in the analytical capacity of mass spectrometry now offer biological scientists a means to overcome this problem.

Many university scientists do not have direct access to sophisticated, state-of-the-art scientific research instrumentation. This is a serious national problem being addressed through the combined efforts of Federal science agencies, state governments, private industry and by the university community itself. The Federal effort is coordinated by the Office of Science and Technology Policy through the Interagency Committee on University Research Instrumentation. Each participating Federal agency is responsible for supporting university research instrumentation in relation to agency missions and programmatic needs.

The Department's response to this overall national effort is the University Research Instrumentation Program initiated in FY 1984 to help support the purchase on a competitive basis by university researchers of state-of-the-art instrumentation costing in excess of $100,000.

The FY 1986 request for the University Research Instrumentation program is $4.5 million. This level will support an estimated 15 competitively selected awards for instrumentation costing over $100,000. As in prior years, the program will concentrate on those university research groups which have already demonstrated expertise in one of a small number of high priority energy-related topics which are of special concern to the Department's research programs. Among the topics to be considered in FY 1986 are catalysis, bioconversion, engineering research including materials, the geological sciences, and environmental research. Each award will be cost-shared with the selected university.

MULTIPROGRAM LABORATORIES FACILITIES SUPPORT

The FY 1986 request for the Multiprogram Laboratories Facilities Support (MLFS) program is $51.2 million (Table 12). The MLFS program consists of two subprograms: Multiprogram General Purpose Facilities (MGPF), initiated in FY 1981, and Environmental Compliance. The goal of the MGPF subprogram, which is managed for the Department by the Office of Energy Research, is to rehabilitate and replace multiprogram general support facilities that are essential to continued operations of the Department's multiprogram laboratory sites. These support facilities include site utilities and support buildings such as laboratories, office buildings and warehouses, roads and railroads, which represent a multibillion dollar government investment.

Through continued use and aging, support facilities deteriorate to a point where they are no longer capable of performing their intended functions and must be rehabilitated or replaced. The MGPF program

Table 12
Multiprogram Laboratories Facilities Support
Budget Authority
($ in millions)

	FY 1985 Estimate	FY 1986 Request
Operating Expenses		
Environmental Compliance	$ --a/	$12.9
Capital Equipment		
Environmental Compliance	--	1.0
Construction		
Multiprogram General Purpose Facilities	33.2	29.3
Environmental Compliance	--	8.0
Total MLFS	$33.2	$51.2

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a/ Pending approval of a reprogramming request, $5.4 million will be devoted to this activity in FY 1985.

systematically reduces the backlog of deficiencies of these support facilities. It reflects an appropriate Federal responsibility for management of the Government's real property, and we plan to continue the program as a necessary cost of doing business as long as the multiprogram laboratory facilities are used to perform research and development functions for the Department.

The FY 1986 Construction budget request for MGPF is $29.3 million (Table 13) and would continue construction on projects begun in prior years, including chilled water facilities at Brookhaven, Oak Ridge and Argonne National Laboratories, medical facilities at Lawrence Livermore National Laboratory, a fire alarm system at Richland, and an environmental monitoring system at Oak Ridge National Laboratory. The FY 1986 request also includes one new project for fire protection improvements at Brookhaven.

Environmental Compliance is a separate subprogram in FY 1986 because of the magnitude of the requirements at Oak Ridge National Laboratory. As such, it will identify and correct deficiencies at ORNL to ensure compliance with existing state and federal regulations. Over the years, ORNL has generated a variety of radioactive and nonradioactive pollutants which were handled in accordance with existing environmental regulations. A number of new regulatory requirements have resulted in the application of more stringent environmental criteria. As a result, long-established procedures and approaches to handling hazardous wastes are no longer acceptable.

Table 13
Multiprogram Laboratories Facilities Support (MLFS)
Budget Authority
($ in millions)

Construction	TEC	FY 1986 Request
New Projects		
Fire Protection Improvements, BNL (86-R-726)	$ 3.0	$ 0.5
Prior Year Ongoing Projects		
Central Chilled Water Facility, BNL (85-R-701)	15.0	7.1
Replace Laboratory Roofs, ANL (85-R-702)	9.8	3.1
Electrical Distribution System Restoration, ORNL (85-R-703)	2.2	1.4
Medical Facility Replacement, LLNL (85-R-706)	7.3	2.8
Replace Site Fire Alarm System, RL (85-R-707)	4.8	3.6
Establish a Central Chilled Water Plant, ANL (85-R-709)	5.2	1.0
Upgrade Environmental Monitoring, ORNL (85-R-711)	3.5	2.5
Modify Central Chilled Water Plant, ORNL (85-R-712)	4.7	2.2
Idaho Engineering Research Lab, INEL (80-ES-11)	19.5	0.7
Road Repairs, RL, LBL, INEL, ANL (84-ER-103)	19.5	4.4
Total		$29.3

The Department is currently working to fully determine the actions necessary to bring ORNL into compliance with all applicable regulations. The Environmental Compliance FY 1986 budget request of $21.9 million will allow initiation of activities to correct environmental deficiencies at ORNL (Table 14). The Operating Expenses request of $12.9 million will allow initial activities in the following areas: process waste system upgrades, hazardous and toxic material management, watershed discharge improvements, spill site characterization and cleanup and upgrades of sanitary and storm sewers. The Capital Equipment request of $1.0 million is for equipment necessary to provide for the cleanup activities. The Construction request of $8.0 million is for general plant projects and design work for the Non-radiological Process Waste Treatment Project. The Department has proposed a $5.4 million reprogramming in FY 1985 to initiate this activity.

ADVISORY AND OVERSIGHT PROGRAM DIRECTION AND POLICY AND MANAGEMENT

The FY 1986 budget request for Advisory and Oversight Program Direction is $2.9 million. These funds are required to provide for the salaries, benefits, travel and other expenses associated with 44 full-time equivalents. The FY 1986 request will provide the staffing resources required by the Director of Energy Research to carry out his responsibilities under legislation (P.L. 95-91) and those mandated by the Secretary in areas beyond the scope of other ongoing Energy Research programs.

Table 14
Environmental Compliance
Budget Authority
($ in millions)

	FY 1985 Estimate	FY 1986 Request
Operating Expenses	$ 0[a]	$12.9
Capital Equipment	0	1.0
Construction	0	8.0
Total	$ 0[a]	$21.9

Pending approval of a reprogramming

[a] Pending approval of a reprogramming request, $5.4 million will be devoted to this activity in FY 1985.

The FY 1986 budget request for Policy and Management is $.5 million. These funds are required to provide for the salaries and related expenses associated with 8 full-time equivalents in the Office of the Director of Energy Research.

Mr. Chairman, that concludes my testimony. I would be happy to answer your questions.

Senator **Domenici**. I appreciate that, Doctor, and we will submit additional questions to you based on your testimony, and if any other Senators on either side have additional ones, we'll submit them promptly. We will ask them to get us the questions in the next 4 or 5 days and ask that you answer them in the next 15 or 20 days.

Doctor, back in the late 1970's, we paid a considerable amount of attention to the health records of shipyard workers who had been exposed to nuclear reactors. Your office is managing an effort, as I understand it, by Johns Hopkins to conduct a thorough study of these workers. We received some testimony during Secretary Herrington's nomination hearing here to the effect that these studies were flawed.

An advisory group set up by you made some recommendations on how to improve the credibility of the program. What are you doing to implement these new studies to correct flaws that were there?

Dr. **Trivelpiece**. Well, I would dispute the statement that they are flawed. I think there is a perceptional problem in these, and perhaps the public has not been made aware of these studies in the most effective manner.

We have set up a "hot line" and we have done additional peer reviews of them, and the Health and Environmental Research Advisory Committee that was established to help guide us in this effort has commented on these programs and said that this is a proper function for the Department and that the Department does a good job at it. I think we can do a better job at making sure that the information is available to those who need it in a timely fashion, but I believe it's more of a perception problem than it is a reality problem.

Senator **Domenici**. So that if it is that, you are doing something to correct, to offer to those who have a perception problem, you're doing whatever you can to alleviate that situation?

Dr. **Trivelpiece**. I believe so.

Senator **Domenici**. Obviously, the Department has had a difficult time because the Health and Environmental Research Program has been cut in half since 1978. We've talked before about how these cuts appear to be spread equally, which sometimes is not the best way toward good programs and necessary programs, as well as those that are not as necessary and not as good.

Have you done anything to turn that around in this set of budget assumptions that you're working off?

Dr. **Trivelpiece**. Yes; the Health and Environmental Research Advisory Committee, which I mentioned earlier, has been used to review almost all the elements of the program—the 5-year plan, complex chemical mixtures, and other technical aspects of the program.

Some changes have been made in response to that review. The program was given, in this rather difficult budget circumstance, about as much favored treatment as could be expected, in that it was held approximately at constant dollar value, whereas other programs in the Department were in fact reduced by 10 percent below the freeze level.

So, to that extent, Secretary Hodel, when the budget was formed, did take special account and note of this program and to the best of our ability within the constraints that we had to live with, tried to emphasize it. There are some changes that have been made within the structure of the program along lines you suggest.

Senator DOMENICI. And is the advisory group looking at that problem and giving advice on where the emphasis might be greater and where it might be less?

Dr. TRIVELPIECE. Yes.

Senator DOMENICI. Your budget request calls for reduction in the operating time for the high energy and nuclear physics from 55 to 45 percent of capacity. At the same time, I'm familiar with the proton storage ring and the neuron research facility at Los Alamos, which has very marginal funding for its startup. It doesn't have experimental hauls for users of the facility, which is a highly recommended step by your own advisory board.

My point is, aren't we doing something wrong when we can't run our existing facilities or properly operate our new ones? Maybe the best way to handle this is to ask you if you would provide the operating budgets for fiscal years 1985 and 1986 for these facilities and their operating times.

First you can comment generally, and then would you submit those budget numbers for us?

Dr. TRIVELPIECE. The operating time is itself kind of a slippery concept; that you couldn't operate the accelerators 100 percent time anyway because of maintenance and setting up new experiments and so on.

I think the percentage number that is used is more of a guide as to the trend, and indeed the trend is down this year, reflecting the budget constraints under which we're operating.

Senator DOMENICI. But you'll furnish us the details on that.

Dr. TRIVELPIECE. Certainly, Mr. Chairman.

[The information follows:]

Facility Operations
(B/A in thousands of dollars)

	FY 1985	FY 1986
Nuclear Physics Accelerator Facility		
ANL—ATLAS	$ 2,795	$ 2,795
BNL--Double MP Tandem	1,500	3,550
LBL—Bevalac	17,360	17,780
LBL--88-Inch Cyclotron	2,110	2,150
LANL—LAMPF [a]	39,245	39,765
MIT--Bates	5,675	5,675
ORNL—Holifield	4,955	4,955
Dedicated On-Campus [b]	3,140	3,140

[a] Includes Defense Programs support of LAMPF Operations - $3,100,000 in FY 1985.

[b] Dedicated on-campus accelerators include Duke University, Texas A&M University, University of Washington, and Yale University.

	FY 1985	FY 1986
High Energy Physics Accelerator Facility		
Brookhaven National Laboratory	36,265	37,400
Fermi National Accelerator Laboratory	83,520	90,700
Stanford Linear Accelerator Center	50,850	54,700
Basic Energy Sciences		
High Flux Beam Reactor (HFBR)	8,095	8,500
National Synchrotron Light Source (NSLS)	14,755	16,850
Intense Pulsed Neutron Source (IPNS)	4,250	5,000
High Voltage Electron Microscope-Tandem Facility (HVEM)	1,120	1,150
Oak Ridge Electron Linear Accelerator (ORELA)	1,700	1,700
High Flux Isotope Reactor (HFIR)	7,800	8,900
Combustion Research Facility (CRF)	3,375	3,375
National Center for Electron Microscopy (NCEM)	1,400	1,400
Stanford Synchrotron Radiation Laboratory (SSRL)	8,040	8,316
Spallation Neutron Research Facility (SNR)	300	700

FACILITY OPERATING TIME

	FY 1985	FY 1986
Basic Energy Sciences Facilities (Percent Utilization)		
High Flux Beam Reactor (HFBR)	76	76
National Synchrotron Light Source (NSLS)	79	85
Intense Pulsed Neutron Source (IPNS)	58	58
High Voltage Electron Microscope-Tandem Facility (HVEM)	80	80
Oak Ridge Electron Linear Accelerator (ORELA)	75	66
High Flux Isotope Reactor (HFIR)	90	90
Combustion Research Facility (CRF)	96	78
National Center for Electron Microscopy (NCEM)	60	55
Stanford Synchrotron Radiation Laboratory (SSRL)	88	64
Spallation Neutron Research Facility (SNR)	12	0
Nuclear Physics Facilities (Percent Utilization)		
Argonne National Laboratory--Argonne Tandem Linear Accelerator System	43	58
Brookhaven National Laboratory--Double MP Tandem/	38	31
Lawrence Berkeley Laboratory--SuperHILAC/Bevalac	58	55
Lawrence Berkeley Laboratory--88-Inch Cyclotron	54	49
Los Alamos National Laboratory--Los Alamos Mason Physics Facility (LAMPF)	67	53
Masschusetts Institute of Technology--Bates	61	42
Oak Ridge National Laboratory--Holifield	67	58
On-campus Accelerators*	77	66
High Energy Physics Faciltles (Percent Utilization)		
Brookhaven National Laboratory (Alternating Gradient Synchrotron)	55	52
Fermilab (Tevatron)	47	43
Stanford Linear Accelerator Center (Linear Accelerator, Stanford Positron Electron Asymmetric Ring, Positron Electron Project)	52	43

*Yale University, Duke University, University of Washington, Texas A&M University

Senator **Domenici**. The Superconducting Super Collider, could you summarize where we are in terms of how we're going to pay for it, given the difficulties of operating existing facilities, and what could be done to assure that we don't kill a generation of scientists by closing down today's machines in order to start the buildup of a new machine which is going to take a long time. The cost might be set off against scientists.

Dr. **Trivelpiece**. I was hoping you were going to tell me how we were going to pay for it.

Senator **Domenici**. Fine, I might.

Dr. **Trivelpiece**. The program got started 2 years ago in effect, in a limited way when the Isabel Accelerator activity was terminated and the remaining funds for it were reprogrammed into the beginning efforts to define what the SSC would cost, what it would consist of, how long it would take, what the technical specifications were.

This year we're spending approximately $20 million and we've requested $20 million again for next year. What that will provide us is the necessary information regarding magnets, magnet designs to determine whether or not some of the cost-reducing design assumptions that were taken into account in the first design studies are in fact valid.

We estimate that the cost in 1984 dollars is about $4 billion, and that the as-appropriated dollars would be around $6 billion. We have put in place a central design group at Berkeley and that group is working on trying to provide this kind of information for us. But as to how it would be paid for, I presume you're implying, are we working to get international cooperation; are we looking to what might be available by contributions from the States and so on? Certainly the States in various regions of the country have indicated a strong interest, and I would presume that any one of them would be certainly in a position to supply land and/or other apparatuses associated with this proposed facility.

Senator **Domenici**. I guess what I'm saying, Doctor, and I was being facetious because I don't know how you're going to do it, but I think we have added a new ingredient to the equation for evaluating the timeliness, because if my statement is true that in order to start paying for it we have to dramatically reduce or terminate programs that have existing super-scientific manpower attendant, that ought to be put into the equation as to when we can afford to do the new big one. And I assume that's occurring, is it not?

Dr. **Trivelpiece**. I agree. And yes, it is.

Senator **Domenici**. One last question. I want to congratulate you on your efforts to get the cost-shared Fellowship Program underway in DOE, and I'd like you to give us just a few details, if you have them, on who is participating.

I think one of the best kept secrets is DOE's Postdoctorate Fellow Program. I happen to think that's one of the terribly urgent times in the life of our scientists. And you look around the country, and they get up to doctorate, and they still need a few years. It's almost shameful to find that they can't find any good work to get on with their basic development. And DOE does a marvelous job, and you're moving in the direction of making that even better.

Can you give us some details on who is participating, Doctor?

Dr. **Trivelpiece**. First, thank you, Mr. Chairman. Several of the laboratories have, in response to our request, submitted proposals as to how they would go about bringing in individuals from industry and other postdoctoral fellows to the laboratories to work on programs. Sufficient time hasn't gone by to permit us to actually get an individual from an institution into the laboratories. But I believe it will happen very soon. The announcements have gone out and the proposals have been received, and we will shortly be in the process of evaluating them.

I think it's an excellent opportunity, and I thank you.

Senator **Domenici**. Would you do us a favor? For the record, so that we will be able to share with everyone here and anyone else that is interested, would you provide for the record the status of the old Postdoctoral Fellowship Program, so we will know what it is, what it did?

We don't expect you to have that here, but if you could provide that for the record we'd appreciate it.

Dr. **Trivelpiece**. Certainly, Mr. Chairman.

[The information follows:]

DETAILS OF INDUSTRY/LABORATORY POST-DOC FELLOWSHIP

Industry/DOE Laboratory Post-Doc Fellowships

A pilot effort termed the "DOE-Industry Technology Exchange Research Program" was announced to all of the major DOE Laboratories in December, 1984. The purpose of this effort will be to promote the transfer of laboratory developed research and technology to industry through providing opportunities for about eight industrial scientists to become thoroughly acquainted with laboratory research programs, facilities and capabilities. Strong expressions of interest have been received from eight laboratories. These labs have been asked to identify research areas of potential interest to industries not already significantly involved with the laboratories. Following the identification of these areas, specific industrial companies will be selected to send scientists to a laboratory for one year visiting research appointments. DOE will provide funds for the salary and living expenses of the visiting industrial scientist along with some contribution from his or her home company. We expect to approve the specific arrangements proposed by each laboratory by June 1, 1985. DOE plans to continue this program in FY 1986.

We view this effort as an expansion of our current postdoctoral research program which each year brings about 350 young university scientists to our laboratories. This new effort will provide us with a unique opportunity to help facilitate interactions between the laboratories and the industrial R&D community. The program will also contribute to identifying those resources and technological developments in the laboratory that can be applied or make a contribution to industrial innovation.

University/Laboratory Post-Doc Fellowships

The traditional post-doctoral program with universities continues at all of the major DOE research laboratories with the largest number of appointments occurring in the basic sciences of physics, chemistry and the biological and life sciences. For FY 1985 the total number of post-doc appointments is expected to be about 430. At the conclusion of these assignments the researcher may remain at the laboratory as a contractor employee or return to the university as a researcher and teacher.

Senator DOMENICI. For those Senators who arrived after I started, I indicated that Senator Ford was at another hearing on Conrail and could not be here. If we finish before he arrives, he will submit questions for the record.

I have to leave in about 10 minutes, and we have one additional witness. Clearly, I can leave the hearing in your hands if we have to go beyond that time, Senator.

Senator EVANS. That may be dangerous.

Senator DOMENICI. Not at all. In good hands, better hands that presently presiding.

I yield now to Senator Bingaman.

Senator BINGAMAN. Thank you very much, Mr. Chairman. I appreciate the chance to be here and ask a few questions even though I'm not a member of this subcommittee.

I wanted to ask you, Doctor, just a couple of other questions related to what the chairman has already asked. I've become interested just recently in the Distinguished Scientist Program DOE has funded. I gather you started this initiative last June and it's going forward at the University of Tennessee in conjunction with Oak Ridge.

Maybe you could just describe that in a little detail if you could. I've explored at the staff level with the Department of Energy the possibility of doing something similar to that in New Mexico, and I'd be interested in any comments you'd have on how that works.

Dr. TRIVELPIECE. I think it works very well. It is a combination of funding from both the State and through the Department. The Department's part represents not an "in perpetuity" commitment, but it is in part on the basis of scientific merit that the individuals bring.

And the distinguished scientists are then brought to the laboratory to work closely with the university. To some extent, each of the laboratories do that, as does Los Alamos. Los Alamos has various distinguished scientists programs, and it brings in people from time to time, both on contract funds and other funds that are available to them.

To some extent DOE laboratories are collections of distinguished scientists, and it is, however, useful from time to time to create some special categories for particular recognition and bring individuals in for these kinds of purposes.

We don't have a formal program to do so, but certainly there is no prohibition on the laboratories from doing it within the available funds they have.

Senator BINGAMAN. I guess the part of the program that was of particular interest to me was the sort of formal tie that you had between the laboratory in Tennessee/Oak Ridge, and the University of Tennessee, which I was not familiar with in our State where you actually had some of these people being made available to the university for research and other types of activities.

Dr. TRIVELPIECE. That kind of a formal agreement certainly does emphasize the laboratory/university tie and has some special benefits that attach to it as a result.

We certainly would be interested in such a program and have no objection to it. In some sense, it depends on the laboratory and the university establishing the appropriate relationship and then the academic institution or the State providing some of the funds or a tenure position for the individual.

Senator **Bingaman**. Then, as I understand, the Department of Energy's thought is that if one of our national laboratories and an appropriate university were to work this out—for example, in my home State—and the State were to make an appropriate commitment of resources to it, then the Department of Energy would stand ready to try to do so as well.

Dr. **Trivelpiece**. Yes. Within the restrictions of the appropriateness of the technical programs and so on. And I would presume that the individuals would be mutually acceptable to both the academic institution and the laboratory, and that program funds would be available.

Senator **Bingaman**. OK. That's a subject that we may want to follow up more with you on in the future if we could.

Let me just ask something that Senator Domenici was asking about, because I was not here to hear the answer on it; the question of funding for the Los Alamos Laboratory's proton storage ring facility, ı gather that there is a problem there with the experimental halls being funded in the 1986 budget.

What is your position on that?

Dr. **Trivelpiece**. Well, we did not request the funds for that hall. But yes, we believe that it should be in there. And if it isn't in there this year, we should probably try to see what we can do about it next year.

Senator **Bingaman**. So as the budget now stands, or as submitted, it's not in there, but you do believe it's a high priority item?

Dr. **Trivelpiece**. It's a very high priority item. Yes, sir.

Senator **Bingaman**. OK.

Let me ask, a question in the general area of the Basic Energy Science program. I notice in your testimony, you put a lot of emphasis on the importance of this program, which I certainly agree with. But it appears that this is the first year, at least since 1981, that we have actually seen a requested reduction in funding by the administration for the Basic Energy Sciences program in your Department.

I'm concerned, I guess, that if we're asking for a reduction in funding of that area this year, we have a series of years ahead of us where budget constraints are going to be very real, at least as real as they are this year.

Is this a bad trend? Is this something that the Congress should go along with? Are we going to see a sort of deterioration of our commitment in this area?

Dr. **Trivelpiece**. Certainly the President has favored science and technology, and as a result, these programs within the Department over the past few years have received favored treatment, and they have grown rather substantially.

It is true that this year, this program is being held at approximately a constant level. It is an accommodation to try to balance between the need for deficit control and to emphasize science and technology.

I hope it does not represent a trend, and I hope that the trend to try to provide a solid base for these activities within the Department continues in the future. It's a difficult compromise and there's no need to pretend that it is easy to do this this year.

Senator **Bingaman**. Can you see any factors that would justify us reducing funding in this area this year that will not be there again next year and the year after and the year after?

Dr. **Trivelpiece**. That would be very speculative. I'd have trouble talking about that in the general terms that you're requesting. In terms of specific technical programs, I can probably be more specific.

Senator **Bingaman**. Well, let me ask in a slightly different area, and this will be my last question, I'm somewhat concerned about the trend in military R&D as compared to civilian R&D as funded by the Federal Government.

My information is that military R&D since 1981 has really more than doubled, from $16.9 to $37.3 billion. And even if you discount for inflation, you have a real increase of 79 percent.

On the other hand, civilian R&D has gone from $15.6 to $16.017 billion, an increase of 3 percent in real terms, if you discount again for inflation, you see a decline of 28 percent.

Again, I am just worried about the long-term trend here of reducing Federal Government support for civilian R&D which your Department has a good deal of responsibility for, and increasing our support for military R&D at the same time—if that trend is appropriate in your opinion, if it's something we should continue.

We have gone a long way in that direction in the first part of this decade.

Dr. **Trivelpiece**. I don't suppose that I am qualified to really comment on the global aspect of military versus civilian. Each of these programs are argued within the administration on the basis of their merits.

To that extent, I've had a very fair hearing within the Department and within the administration in terms of basic research as supported by the Department. It has grown rather substantially in this administration. We're very pleased about that.

So I'm not in a position to say that things have been cut, but rather that they have grown even more than the trends that you're indicating. In fact, I think basic research in the Department has nearly doubled since the beginning of the Administration, and that has been with the strong support of the President.

Senator **Bingaman**. So you see this 1-year reduction in funding on the basic energy sciences as an aberration.

Dr. **Trivelpiece**. I hope so.

Senator **Bingaman**. OK. Certainly an aberration as to what has gone in the last few years in your Department.

Dr. **Trivelpiece**. Yes; well, I hope our budget situation is an aberration globally.

Senator **Bingaman**. I hope so, too. I hope it's a temporary aberration. I think Senator Domenici shares that opinion.

Thank you very much. I appreciate the chance to ask questions here.

Senator **Domenici**. Hope springs eternal.

I'm going to have to leave shortly and turn the meeting over to Senator Evans. Let me say, however, to our one outside witness, Dr. Stephen O. Dean, president of Fusion Power Associates, Gaithersburg, MD—we do welcome you—where are you? And I'm sorry that I won't hear your testimony. But I am genuinely concerned and will make sure that I read it and understand it.

I would tell you that within the last 3 or 4 days, I had a very interesting conversation about fusion energy. I can't—I don't think I should reveal which one, but one of the major networks of the United States, through their president of the news part of the network, sat by me at an evening event. And normally there isn't much of substance discussed at those kinds of events, but an interesting question was asked, and that was, should the American people and the world understand the potential for fusion energy on humankind?

And that was very exciting to me because I didn't have any difficulty asking him if he was serious, because I don't find very many news organizations that look at things like fusion in that perspective and so I proceeded to tell him my philosophy about it. I think most problems that humankind has are ours, and I don't think there are any instant kind of cures. So my notion is that if there are hungry people and if there are energy shortages in the world, I don't like to attribute it to populations and the like; I like to attribute it to the fact that there are things we haven't done that we can do.

And I told him that, and said that's how I look at fusion energy. If we will stay on it, that is one of our—humankind's—potential solutions to innumerable problems. And I for one think that's exactly the kind of thing we ought to do when we have great talent and great technical skills, and so I encourage you to do it, and I assume that if it stays on, there will be a major national evaluation on one of the networks of this kind of a potential event.

Dr. Dean. Thank you. The Fusion Program has appreciated your support over many years, Senator.

Senator Domenici. I'm going to now turn the subcommittee over to Mr. Evans and thank you very much, Doctor, and thank you very much.

Senator Evans [presiding]. Thank you, Mr. Chairman. I'm not sure I should ask the question, much less get the answer, but for this engineer trained in a different era, can you just for a few moments describe what we're aiming at, what we have found out?

I've read your testimony and I know what you said in there. But just give me a general view of what the investment in high energy and physics, the increasingly large accelerators, what direction is it taking, what value are we getting out of it? What discoveries? What do we hope for?

Dr. Trivelpiece. Well, if I knew what discoveries there were going to be, I wouldn't——

Senator Evans. I understand that.

Dr. Trivelpiece. That's a classic dilemma in trying to explain these programs.

Senator Evans. Perhaps looking backward a short time. I know that you did speak to that in some of your testimony.

Dr. Trivelpiece. Well, it's in an interesting sequence of things; if you start back in the early 1930's, we knew about an electron, a proton, and a neutron, and then some cosmic ray experiments in the mid-1930's revealed that there were things that had masses in between those of protons and electrons and, furthermore, that there were things that had the same physical characteristics except that they were the antiparticle, the positrons and so on.

And a whole collection of new mysteries began to appear. There were things inside the atom that had not been previously known to be there.

As cyclotrons and other accelerators came into being, it was possible to explore these in a more efficient way than by simply waiting for cosmic rays to strike through cloud chambers.

The collection of the elementary particles then grew and grew, to the point that it was clear that this is a very complex situation. As is sometimes the case as with BOHR, realizing that perhaps atoms are constructed by electrons going around in circles, and Mendeleev putting things in the periodic element tables, some physicists decided that perhaps life is simpler than that and proposed that quarks were the interior part of the nuclear matter.

As a result of that, instead of having a hundred or so elementary particles, it has now in the last 10 years or 15 years been realized that you can construct everything we see from two classes of things—quarks and leptons—and that there are six quarks and that, for instance, the proton contains two ups and a down quark. And so from that, if you can take quarks and build protons, and protons and build atoms, and atoms build things——

Senator EVANS. And what we thought were many different things were just various manipulations of those fundamental particles.

Dr. TRIVELPIECE. That appears to be the case, certainly among the more fundamental particles. Now, are they the most fundmental? Well, that's always a hard question to answer, but as a result of the picture that has emerged, the quark-lepton picture of matter, you can take six quarks and six leptons and from them explain almost everything that you see. There are still some things that aren't understood, like why does a proton have the mass that it does; or why does an electron have the mass that it does? What's the absolute scale, and what are the forces that hold these things together?

If you think about something like a sphere of gas, like water, H_2O that's at high temperature, you have a very simple law of physics in effect. You have marbles essentially batting back and forth. As you reduce this temperature, water condenses out, so you now have gas and water and an exchange between them and some kind of a phase transition that occurs. So you need a more complicated explanation for nature if that happens to be the world in which you live.

If you reduce the temperature even further, you then get ice. Ice is a solid, and has different laws of physics which affect it; water has its laws of physics; there's transitions in between, and so on. Life has become very complicated.

To some extent, the world in which we live has that characteristic. It is a relatively low-temperature world compared with the world that probably existed sometime at the beginning of what we regard as the universe or the big bang; that during the very early few small fractions of a second, that things were at such a high temperature that there was a fairly simple law of physics in effect;

and as things have cooled down, we then end up with these condensed planets on which we live and condensed forms of matter which we see.

Part of the struggle or the interest is to go back and try to find out what are the most elementary particles and what are the forces that guide their behavior. To that extent, at the present level of energy that is achievable with the accelerators that are available around the world, there are some remaining predictions, theoretical predictions, based on the model as it is understood, that would help clarify what are the intrinsic levels of mass and why are they there.

It becomes a question of cost-effectiveness at some point, and indeed the kinds of funds that are needed to build the next generation of accelerator are rather large, and what do we get back for that in return for that kind of an investment? In the past, of course, it has been very profitable to the country, and I think a significant fraction of our gross national product owes its existence to things that you can go back to the early 1930's and attribute to high energy and nuclear physics research—the nuclear power industry, radiation processing of materials. The whole nuclear medicine industry has certain of its origins back in that period, things like PET scans, nuclear magnetic resonance are all in some sense derivatives of information gained as a result of the curiosity-driven activities to understand what the interior of the atom is and what it does.

Looking forward, I would confess it somewhat harder to make the case, but it is always hard to make the case forward. It is easier to make the case looking back in terms of what has resulted from these things.

I realize that's a long answer to a short question, but I don't know how to answer the question in a succinct way.

Senator EVANS. I think you just did. That was a remarkably lucid and very helpful answer.

It seems to me that it probably is valuable to look backward and to identify as accurately as possible those derivatives, the good that has come from past research. That's probably the best argument for continuing and expanding I know. It's perhaps the only one that we can really use.

What is the need for the larger and more powerful accelerators? Is it to gain additional speed? Does that give us additional heat of collision? What do we get with larger and more powerful?

Dr. TRIVELPIECE. Well, it essentially makes it possible to look on a smaller and smaller space scale. The higher the energy, the more resolution you can obtain.

Let me give a simple example of what an energy threshold involves in some sense. If you have an electron and a positron, which is its antimatter particle, when you bring them together they annihilate one another and give off two rays of energy, two gamma rays at a precise energy.

If you bring them together at a higher and higher energy, eventually you reach the point where there is a local concentration of energy as they annihilate that is capable of coalescing backward and forming matter again.

So Einstein's famous formula which says E equals MC^2 works both ways. You can in fact cause these particles to come together at a high enough energy such that the energy converts to mass rather than as occurs in nuclear fission reactors where mass converts itself to energy. It can go both ways.

So an accelerator like the Stanford Linear Accelerator causes electrons and positrons to come together at very high energy and, as a result, can then produce new states of matter, new pieces of matter that didn't heretofore exist, and do it in a very precise and controlled way and study them.

And so there are thresholds. The amount of energy that you need to create the new piece of matter is what's going to determine the mass. So the higher the energy that you can bring into this collision, the greater the mass.

And so it is with the proposed superconducting super collider. The accelerator at CERNE which is the European National Laboratory for High Energy Physics, just this last year or so discovered two particles called the W plus and minus, as well as another one called the Z°. The W plus and minus are created in just exactly this manner.

Two protons or a proton and an antiproton are brought together at sufficiently high speeds, that when one of the quarks annihilates with its counterpart, that there is enough mass left over to produce something that is in fact 80 times heavier than either of the protons that came in to produce it.

The next energy scale that is required to look at further refinements on understanding matter requires something capable of producing particles 1,000 times heavier than a proton. What that takes is something in the units of energy that physicists use; 20 tetra-electron volt protons will have to collide with 20 tera-electron volt protons in order that there be, in the random events that occur, an annihilation plus enough energy left over to prove something that has a substantially greater mass than the proton and greater than we have done so far.

Senator EVANS. Do you liken this really to the stretching out of research into inner space as just the corollary of whatever we choose to do in terms of space stations and space telescopes and reaching out in the other direction?

Dr. TRIVELPIECE. Probably one of mankind's most distinguishing characteristics is the curiosity to know what's around the corner and across the mountain and so on. And certainly this is one of the frontiers that is left. And as Vannever Bush referred to it many years ago, it's the endless frontier. It obviously has a cost-effectiveness coefficient to it, and to some extent that's more of a matter of a national priority, and the administration together with the Congress have to sort some of these things out. Our job is to put together the best technical case we can for it, and then it has to be looked at in regard to national priorities with cost-effectiveness in mind.

Senator EVANS. Turning to the money side of it for a moment, with the building of these larger and larger accelerators, is there still a full need and full value of the smaller and older ones which we have built in the past, or do they ultimately become really nonusable or irrelevant?

Dr. **Trivelpiece**. Certainly that does occur. Twenty-five or thirty years ago, virtually every university had its own accelerator. Then as the frontier to do research required accelerators with more energy and thereby costing more, the various coalitions of universities were formed, national laboratories came into existence, and at this point what we have is three national laboratories doing high energy physics research, and instead of an accelerator at 100 universities, we have 100 universities going to Fermi Lab and SLAC and Brookhaven.

If you look down the collection of accelerators that used to exist, you realize that the community that does this research has been very good at terminating those activities that are no longer productive, but there is a kind of gray area which you alluded to, and that is there is a point at which they become very useful as training tools for scientists. They may not be the critical frontier element, but they are very useful for scientific training, and there is some need to maintain balance in this.

Senator **Evans**. What about on the international scale? I presume other countries are engaged in the same sort of research. How much interchange is there? How much cooperation is appropriate to carry forward? And as a result, how much more efficiently can we make our investments in these kinds of big machines?

Dr. **Trivelpiece**. There's been a substantial concern on this subject over the last few years, and fortunately, as sometimes occurs, a tool or device with which to deal with some of the problems occurs at about the same time you need it.

The Versailles summit process included a suggestion that science and technology are important to the overall economic health and well-being of the summit countries. Mr. Mitterand proposed that there be an examination of areas in which enhanced collaboration or cooperation might take place.

There were some 18 areas identified. One of these was fusion and one was high energy physics. It turns out that the United States is the leader for the high energy physics activities under the Versailles summit process. And I have been the chairman of that committee, and we have met on several occasions now, and most recently in Carderache in France to look at what kinds of cooperation and collaboration there are.

A year ago in July, following the London summit, we met in Brussels, and outlined three things to do, and referred to these in simple terms as the wholesale problem, the retail problem, and the administrative obstacles problem.

Groups met during the year and prepared reports on each of these three areas, and those are the reports that we examined in Carderache and they serve as the basis for the report that is now on the table at the Bonn summit which the President will be attending, in just a few days.

The substance of those are that I think it is clear that if the price tag that we're talking about, the facilities that are being considered, that it is unrealistic and in fact outrageous that several countries should simultaneously build the same device to get the same results at the same time. That's what we call the wholesale problem.

To that extent, the idea is can we come to an agreement among at least the summit countries and perhaps others who should be involved, to have a plan whereby it is not a question of everybody putting the money on the barrelhead and building it off in some other location, but that if the United States builds this facility, then what will be the next facility that Europe would build, and what would Japan build, and what might China build, and so on.

Can we come to a plan, an international agreement, which lays out a plan that avoids unnecessary duplication? That seems to be moving along reasonably well, and we are discussing on a bilateral basis with several countries the possibility for cooperation in this area, and the cooperation has been excellent. And that's sort of the retail level of things.

What can we do within the current program boundaries and funding levels that makes sense? There have been many exchanges of scientists in this program, back and forth between here and CERNE and other laboratories of the world. In fact the discovery that I mentioned earlier, the W plus and minus, was led by a scientist who's a faculty member at Harvard University, Carlo Rubia, for which he received the Nobel Prize for his work in that.

So the cooperation at the retail level is going on very well. I don't know that it could be enhanced any more than it already is.

The administrative obstacles activity I found more revealing in the sense that if the heads of state are really saying that they believe that science and technology are important ingredients in overall economic well-being and that international cooperation need to be enhanced, then what can you do to improve conditions by which cooperation takes place?

It turns out there are a number of minor obstacles that are of a rather vexing nature but really have a significant influence on cooperation. For instance, the Customs requirements on personal property for use in scientific instruments requires that you, after 3 years, pay duty on them. Well, if you're going to build a large facility, and it is for this kind of scientific exchange, it seems sort of pointless to be charging duty on these kinds of things.

However, I think if a physicist were to go and speak to his local Customs official about this, he's not likely to get a very responsive answer. But we have laid on the table for consideration at the Bonn summit these and other kinds of problems—visas, spousal working permits, and so on—that are not major obstacles; they don't prevent things from actually happening, but they clearly make it more difficult to carry out the kind of cooperation that is discussed in the summit process.

Senator EVANS. Does that international cooperation lead across the Iron Curtain? How much interchange in this area of scientific research is shared between scientists on both sides of the curtain?

Dr. TRIVELPIECE. Cooperation with the Soviet Union is, obviously, very carefully measured at the moment, in view of the current circumstances with which we interact with them. But President Nixon and Mr. Breshnev got together in the early 1970's and suggested that certain cooperation would be useful.

From that, then there came agreements in high energy physics, nuclear physics, fusion, and nuclear energy. These agreements were put in place for 10 years. They would have expired in

1983-84, I think. They were renewed for a 5-year period. As a result of these protocols, there are scientists being exchanged from the Soviet Union to the United States in high energy physics. There's a group from Leningrad at Fermi Lab. There's a group, I think, from Moscow also at Fermi Lab, and from time to time our scientists have gone there. They have supplied equipment and people. It's been a very effective exchange, and in this field they are highly qualified scientists.

And it's been bilateral. I think it has not been a one-sided exchange that has been to the benefit of either party in a singular way.

Senator **Evans**. Let me turn for a moment to your basic science program. Several questions, and I guess one observation. I'm curious as to how studies are chosen and picked from what I would guess are many suggestions than there's possible funding for. And the degree to which there is adequate cooperation and coordination with industry and with other laboratories and with higher educational institutions, and whether you believe that there is sufficient consistency in funding in these basic science areas, adequate funding on a continuing basis, so that we can do the necessary building blocks that are important.

And then I guess specifically I'm interested in two areas of research that it seems to me have some real potential. I'm curious as to how much is being done and whether we're adequately enough looking into them, or whether it's even your responsibility.

The first is in the very broad area of energy efficiencies; we call it conservation; I much prefer the term efficiencies with the understanding that about half of energy produced now goes to waste. Some of that, obviously, is necessary waste, just in the physics of the use of energy, but it seems to me that there is an enormous potential, perhaps a potential that is as inexpensively reached as any other in terms of more efficient use of energy, whether it's more efficient combustion, just down through the ranges of areas to cut down waste.

And the other is in a fundamental fuel. It seems to me if we were to describe the perfect fuel, it would be one that had universal—it was universally available, something that had few if any pollutant byproducts. You could describe what it is you want. It seems to me that hydrogen comes about as close to that as any fuel I'm aware of, and I'm curious as to any comments you might have on progress toward the more effective, more economic use of hydrogen as a fuel, whether there are some ultimate barriers in the way of getting there or whether it's just an adequate amount of research that could gain us that economic use.

That's a number of questions all in one, but they all evolve around, I guess, the fundamentals of your basic research program and how you choose studies, and what seems to make the most sense.

Dr. **Trivelpiece**. Let's see if I can answer them in order.

With regard to the first one, it is a collection of excellent programs. They are peer-reviewed, and as you suggest, more unsolicited proposals are received by us than we could ever hope to fund, so there is a rather good culling out process that leads, I think, to good research.

With regard to whether it's adequate or not, we're dealing with a situation in which for more money we could do more research; for less money, we will do less research. But in any case, we are not anywhere near the boundary where we're at risk of reducing the quality of the things that would be done.

So it's all first class and excellent, and I think that the kinds of cooperation between industry and the universities and laboratories, whereas it could be better and we are working at trying to make it better, it is certainly not bad at the moment.

The collection of things that you referred to in conservation, indeed there is——

Senator **Bumpers**. Mr. Trivelpiece, would you pull that microphone a little closer? I guess I'm getting hard of hearing.

Thank you.

Dr. **Trivelpiece**. With regard to conservation and renewables, there is an Assistant Secretary who's responsible for that area specifically within the Department. There are two kinds of things, though, that go into conservation. One occurs at the basic research end, and those are the kinds of things that we're involved in.

A classic example of this is the work that was done by a professor at Cal Tech, Paul Duwez, who has since passed away. He was concerned and interested in the basic structure of metals and so on. And in order to learn something about metals, he wanted them to be created in a form in which the normal crystalline structure wasn't one of the dominant features.

So in order to get a metal that lacked structure, crystalline structure, he tried cooling it very rapidly. By this rapid process of cooling, he did indeed create a new kind of material, and it's called a glassy metal. These glassy metals have now found their way into hundreds of applications. One of the applications will be—and it is now being done and it hasn't been done as much as the economics would dictate would be useful because it's a replacement problem as well—but if all the transformers that transform electricity in the United States from high voltages to lower voltages were to use this material as the magnetic core, rather than the conventional materials that have been used, the savings to the United States would be in excess of $600 million in electricity.

So there's a conservation type activity that occurs in the basic research domain.

Senator **Evans**. $600 million over what period of time?

Dr. **Trivelpiece**. Per year.

Senator **Evans**. Per year.

Dr. **Trivelpiece**. There are many other applications where the low loss magnetic material, such as a glassy metal, is called for and it works very well. People would like to make solar cells more efficient, and certainly there is a great deal of work that goes on at the engineering level, but there also is concern: Can you make new kinds of materials that will be more efficient? Can you understand the physics and the chemistry of photosynthesis?

For instance, plants know how to do something that we have yet to duplicate or understand the physics and chemistry of in the laboratory. If you could understand that process from a physics or chemistry point of view, then perhaps with genetic engineering or other techniques, it would be possible to create plants whose efficiency was much higher in absorbing sunlight and converting it into matter.

That would be an example of how you could go about doing it. But the sorts of things that involve building efficiency and construction, no, the Energy Research Program doesn't have much to do with that directly. That falls over into the Assistant Secretary for Conservation Renewable.

Senator EVANS. How about the efficiency of combustion?

Dr. TRIVELPIECE. We do manage, in conjunction with some of the other elements in the Department, a Combustion Research Center which is operated by Sandia Laboratories. It's located out at Livermore, CA. That facility is one of the first of its kind that I'm aware of that has in it a tool which is a high-power laser which permits exploration of the combustion process as it takes place. And a number of things have been discovered about what happens in the small fraction of a microsecond when things like methane gas mix with oxygen and combust; that there are a large collection of chemical species that are produced that literally live for only a tenth of a microsecond and yet they have a dominant influence on the outcome of how much goes into carbon monoxide, carbon dioxide, water, and energy.

And so understanding those reactions—the reaction rate—is an important element. So indeed we do have a program that dedicates itself to understanding the physics and chemistry of combustion. Things like the lime injection to reduce sulfur dioxide, and so on—sulfur emissions—grew out of that program support. It's not supported exclusively by Energy Research, however; it also receives support from the Fossil Program as well.

Senator EVANS. I'll defer any response on hydrogen—well, go ahead. How promising is it?

Dr. TRIVELPIECE. Well, hydrogen certainly is a fuel. It's a question of producing it cheaply enough to make it available. There are a number of techniques that are being looked at. Hydrolysis, taking electricity and converting it to hydrogen, is probably not efficient enough to make it worthwhile. It would take something like a photosynthesis process or a material that you could put into water, which when sunlight strikes it, would create local electrolysis and release hydrogen in an efficient way.

I know people are looking at this, and I really don't know what the status of it is. Hydrogen is a readily transportable fuel and does have some advantages, but the dilemma is not that that is the case; the dilemma is how to produce it in a cheap enough manner to make it useful to pump it and store it, and so on.

Senator EVANS. We're not sponsoring any significant research along that line currently?

Dr. TRIVELPIECE. A small amount, and I really am at a loss to know how much and precisely for what. I'd be glad to learn what that is and supply it for the record for you if you'd like.

[The information follows:]

USE OF HYDROGEN FOR ENERGY

Currently the DOE supports about $1,600,000 of research that is directly related to the production, storage, and utilization of hydrogen as a fuel. About 75 percent of this effort is funded by the conservation program. About 25 percent of this work is for basic hydrogen biochemical separation and storage research funded by the Basic Energy Sciences Program. This level is down from the peak years around FY 1980 because of changing priorities and other programmatic demands on the available funds.

Senator EVANS. Senator Bumpers.

Senator BUMPERS. Mr. Trivelpiece—first of all, Mr. Chairman, I ask unanimous consent that my prepared statement be inserted in the record.

Senator EVANS. Without objection, it will be.

[The prepared statement of Senator Bumpers follows:]

STATEMENT OF HON. DALE BUMPERS, A U.S. SENATOR FROM THE STATE OF ARKANSAS

I am pleased that the Committee has begun hearings to consider the Energy Research programs of the Department of Energy. These programs constitute an important element of our energy future. They provide the basic knowledge of some of the broad principles that will allow us to produce our future energy from reliable and plentiful sources.

It is essential that we fund these programs adequately, in the same way that we must fund basic educational programs. In fact, they are related, because much of the money spent by these programs supports sophisticated university research and maintains the highly-trained scientists that we will always need.

There is one troubling aspect, common to the entire Energy Department budget, which this Committee must continue to pursue. That is, what portion of these funds will be devoted, directly or indirectly, to weapons-related research. We have seen in previous hearings on the Department's budget that a growing percentage is devoted to weapons research and development.

I have said before that the most troubling aspect of this trend is that it is somewhat concealed in the budget documents. We have asked the Department more fully to indicate how its requested funds would be divided between military and domestic uses. It is becoming increasingly clear that its budget illustrates what is happening on a broader scale with the entire budget—military concerns are dangerously squeezing out domestic needs.

The Senate must first know the degree to which this trend is continued here, and it must also make the choice between further armaments and a secure energy future derived from the research which the Department must pursue into alternative energy sources.

Senator BUMPERS. My primary concern in energy research is in the area of fusion. Senator Evans may have already covered this with you, but for my own edification, let me just ask you if fusion holds the promise now that we thought it held a few years ago when we first began to put massive infusions of money into this program.

Why are we cutting it back by 10 percent?

Dr. TRIVELPIECE. First, a disclaimer. My written testimony does not include the fusion program at this time, and that was not presumably the subject of the hearing.

Senator EVANS. I should say that there will be another hearing specifically aimed at fusion energy, although we do have one more witness, Dr. Dean, who would not be able to be at the other hearing, so he is testifying today on fusion.

Senator BUMPERS. He is a public witness, as I understand it.

Senator EVANS. That's correct.

Dr. TRIVELPIECE. But I would be delighted to answer the question, although it is not normally the subject of this hearing.

The fusion program was——

Senator BUMPERS. You can advise your cohorts that I'll be here at the next hearing, too.

Dr. TRIVELPIECE. Well, I'll try to give the same answer at the next hearing if you ask the question again. [Laughter.]

The fusion program had been funded at about a $30 million level for several years prior to the oil embargo prices. During that oil embargo, then-President Nixon asked Dixie Lee Ray, who was then the Chairman of the AEC, to come up with a $10 billion energy independence exercise.

As part of that, the fusion program looked at what were the possibilities, and the possibilities at that stage were to plan for a fusion reactor by about the year 2000. If you have a reactor that you can demonstrate by the year 2000, then you need to have done something by the year 1995, correspondingly something else by 1990, 1985, and so on, and you work your way back on that kind of a rollback mode, and you look at where you are, and you come to the conclusion that you're not doing nearly enough in order to make it to that point at that time.

So the program was accelerated rather sharply during that period, and several activities commenced in parallel with the expectation of achieving the goal of the fusion reactor by the year 2000.

In the meantime, the program has done very well. It has met most of its goals and milestones. The situation we find ourselves in now is not in a declining supply of oil at an ever-increasing price and a real fear that we would run out of uranium ore for nuclear reactors, but quite the reverse. Uranium mines are, for the most part, closed. The price of yellow cake uranium ore has gone from $80 a pound to $15 a pound this last January. The supply of oil has gone up; the price has gone down.

And in that particular climate within the administration, we are trying to look at a collection of balanced things. And the question arises: What's the urgency to do fusion in that climate?

Well, I have not been successful at trying to make a case that the urgency is such that we should maintain ourselves on a schedule that would produce a fusion reactor by the year 2000. However, we have tried to then look at things that were being done that were in the program, that anticipated the year 2000 activities, and reduce or slow some of those down in order to try to help meet the budget deficit.

So it is a compromise and reflects in no way any technical difficulties with the program or displeasure with the activities that are going on. In fact, the success is very good. The Tokamak Fusion Test Reactor at Princeton has met and exceeded all of its design goals. It's operating satisfactorily.

At a recent scientific conference, it was reported that they clearly anticipate demonstrating the kind of breakeven conditions that were a part of the original agreement between the then-AEC and Princeton University by the end of 1987. They should make the demonstration of what they refer to as a 1-to-10 megajoule quantity of neutrons produced from fusion reactions by the end of 1988. So there is no question but what it has been successful, it is working, the technical milestones and goals have been achieved, and what we're talking about is a compromise within the Department's overall budget constraints, and fusion was treated no worse than the other programs of the Department. It was a freeze, minus 10 percent.

Senator BUMPERS. How's it treated compared to the military portion of the energy budget?

Dr. TRIVELPIECE. It has not received that level of support. That's correct.

Senator BUMPERS. How much increase is there in this budget for military applications?

Dr. TRIVELPIECE. It's about 10 percent, I believe.

Senator BUMPERS. About 10 percent increase?

Dr. TRIVELPIECE. Yes; but remember that the military, the Defense program's activities are guided by the President's stockpile memorandum which is entered into by the Secretaries of Energy and Defense. So to some extent, the Department in its military programs is not initiating these activities on its own; these are, in part, part of a contract between the Department of Defense and the Department of Energy, with the President's concurrence.

Senator BUMPERS. Mr. Trivelpiece, as far as I'm concerned, that doesn't mean a thing to me.

And my visceral reaction initially to your explanation of why fusion is being cut back is 180 degrees from that rationale that we have a glut of oil and gas right now, and uranium has gone from $80 a pound to $15 a pound, and that that is somehow or other a justification for cutting back on fusion research so that we're no longer under the constraints to produce fusion reactors by the year 2000.

If I thought that we would have enough fusion reactors to satisfy the electrical needs of this country the day we used our last 1,000 feet of gas and our last drop of oil, I'd feel differently about it. But it never happens that way.

Now, right now—and you know, I have made the comment two or three times in this committee, among other things I did before I got into politics, I owned a cemetery, and I got out of it because I found it was impossible to sell those lots to people who were in good health.

And so it is with us. Right now we have a—I like for John Warner to be here. He laughs at everything I say.

Senator WARNER. Particularly that story which I've heard about six times. [Laughter.]

It's worth going over again, every line of it.

Senator BUMPERS. But we have a glut of oil right now. And it's true, uranium supplies are more than adequate. And the reason they are is because we aren't building any reactors. We're not building any lightwater reactors in this country. And in all probability, we're not going to build any more. Until the American people decide that they want nuclear power, we're not going to build any more.

You're aware of our history for the past 10 years in this area.

Dr. TRIVELPIECE. Quite well.

Senator BUMPERS. So to say that fusion ought to be put on the back burner or reduced because uranium is 15 cents a pound, or because we have a temporary glut of oil and gas is really penny-wise and pound-foolish. Now, if this energy resource has any potential at all, or at least anything like we have been led to believe for the past several years it has, I take strong exception to putting it on the back burner because of a temporary state of euphoria in this country about energy supplies.

Dr. TRIVELPIECE. I perhaps didn't characterize it as accurately as I should. I don't think it is due to the temporary euphoria about energy supplies. But it was a difficult compromise within the administration to try to seek to control the deficit wherever possible and at the same time maintain these technical programs. And to that extent, I believe this is a fair compromise.

It is still a $390 million program, and most of the technical elements that were being done are continuing to be done. We have delayed or put off certain construction activities, and have delayed or put off certain technical materials and information that would be needed to make it work by the year 2000. But those things can be picked up later.

But the essential core, the science core and the technical activities that will demonstrate breakeven and so on, we very carefully preserved those.

Senator BUMPERS. What is the time schedule right now for the next generation past the Tokamaks?

Dr. TRIVELPIECE. Difficult to say.

Senator BUMPERS. Do we not have a deadline set?

Dr. TRIVELPIECE. No, sir.

Senator BUMPERS. Do we not have any kind of a schedule set up for that?

Dr. TRIVELPIECE. No; I think that at the moment, the problem is first to demonstrate that you can break even. If you can do that, the analogy is roughly like shining a blow torch on a log; you can keep the log burning as long as the blow torch is going; if you turn it off, if it's just one log, it tends to go out.

The next step is ignition, which is sort of three logs, and three logs will keep burning effectively.

It's much the same with a fusion reactor. There is a byproduct of the fusion reaction itself which is an energetic particle, alpha particle that comes off, and you need to have either a stronger magnetic field to contain it, or a physically larger device in which to have the plasma created in order that that alpha particle heating can cause enough heat to be self-generated to maintain the fusion fire going. Ignition, in other words.

That's the next step beyond where we are. Serious consideration is given now to various proposed designs, but at the moment, we don't have a plan for a device which will produce that at any particular time. But thought and consideration is being given to such a device.

Senator BUMPERS. Well, I think that's tragic and I have just as much concern for the budget and getting the deficits under control as anybody. It's always just a question of priorities. We're unhappily in the posture now of having to choose between very attractive programs.

We're having to choose between Social Security and health care for the poorest people in the country; between student loans and immunizing children. And Senator Warner and Senator Evans and I, none of us, like to have to choose between what we consider to be all very worthwhile programs.

And it's a real tragedy that we've gotten ourselves in this predicament, and here in the Energy Committee, it's a tragedy that we're slowing down research in an area, in my opinion, that should never have been sidetracked. I opposed the cuts last year. We cut how much last year?

Dr. TRIVELPIECE. $40 million.

Senator BUMPERS. How much?

Senator DOMENICI. $40 million.

Senator BUMPERS. $40 million last year. I was opposed to that. Now we come in cutting another $40 million. The budget constraints are going to be just as drastic next year. The necessity will be just as drastic next year as it is this year, and so I suppose we'll cut fusion back another $40 million.

Dr. TRIVELPIECE. Last year it wasn't the administration that cut it.

Senator EVANS. That should be pointed out.

Senator BUMPERS. I know. It was the House that cut it.

Senator EVANS. The House cut it. And we've got a little work to do among our own colleagues.

Senator BUMPERS. Yes; that's true. But as I say, that's just myopic in my opinion.

I won't take anymore of the time, since we're going to have another hearing on this. I thank you for your candid answers, Dr. Trivelpiece.

Dr. TRIVELPIECE. Thank you, Senator.

Senator EVANS. Senator Warner.

Senator WARNER. Thank you, Mr. Chairman.

First, I want to commend my distinguished colleague. He makes his points very forceably, with skillful use of humor, simply an understudy of that giant.

Senator EVANS. Put your hand on your pocketbook, Dale.

Senator BUMPERS. That reminds me of the old country lawyer who said it's like a one-eyed mule; they kick hell out of you when you least expect it.

Senator WARNER. First, I think we're fortunate as a country to have such an able person as the Director of this important function. And I wish to associate myself with the Senator's comments on nuclear propulsion area. I did a lot of work with that when I was in the Department of the Navy. As a matter of fact, I met the Admiral yesterday that's in charge of that program.

The Navy's record is extraordinary. It's just a tragedy that same record could not have been applied to the private sector. I agree that we must not relax our attention.

But moving on to a subject which I have a keen interest in and have followed now for many years, and that's the continuous beam accelerator facility you thoughtfully came into visit the other day. But I think it's important that we include in the record being made today your views about the Department of Energy's High Energy and Nuclear Physics Programs, particularly CEBAF.

Dr. TRIVELPIECE. Well, my views are that we support it. Obviously, that we have requested the funds to begin the activities this year which permitted the recruiting of a Director, and I am pleased that, as you know, Dr. Herman Grunder from Lawrence Berkeley Laboratory will be the Director of the CEBAF project.

We've conducted the appropriate scientific reviews and made the decision to proceed, and we probably would have proceeded with some early elements of the construction this year, but as part of the administration's deficit control program, no new construction starts were permitted for the Department and that's approximately it.

We strongly support the program, Senator. You and I have discussed this on many occasions, and I don't know what additional information you would like in the record.

Senator WARNER. You made it clear this morning. I just want it on the record—full support of the DOE behind going ahead with the CEBAF Program.

Dr. TRIVELPIECE. Yes, sir.

Senator WARNER. It has a high national priority, essential for our long-term scientific endeavor. I thank you.

Senator BUMPERS. Mr. Chairman, may I ask one additional question?

Senator EVANS. Senator Bumpers.

Senator BUMPERS. Then I'm going to have to run.

Pursuing the line of questioning we were in a while ago, about the military portion of this budget, I'm looking at table 10.1 of the Energy part of the 1986 budget, which has been submitted to us by the President.

Well, I'll forego that question. This is not what I thought it was here.

Senator EVANS. While they're looking at that, with the dollars we're talking about in some of these—and let me get back to hydrogen just for a moment. Where would you—where in the various elements of the Energy Department or in other places in the Federal Government would the appropriate further research in bringing hydrogen, or potentially bringing hyrogen to its economic potential really occur?

How much of that is under your office? How much is over in Conservation? Where is it located?

Dr. TRIVELPIECE. I would have to supply a detailed answer for the record because I don't know. But there is some that is being supported within Energy Research, but it is very small in amount. I think it is devoted to trying to find means by which electrolysis can take place, where sunlight will convert to hydrogen efficiently.

Senator EVANS. Do you have any feel or grasp—I know this may be a totally impossible question because it's looking ahead and trying to predict the most suitable and the most likely areas of scientific research.

You say that these programs are very small. It seems to me that—would it be accurate to say that if we found an economic method of transferring water, whatever, into hydrogen, that we would have developed a breakthrough fuel, both for transportation purposes and, for that matter, even firing turbines for electrical production?

Dr. TRIVELPIECE. Well, there's a certain class of things for which hydrogen as a fuel would be quite suitable. And those would have to be determined on the basis of the effectiveness, efficiency, technological problems, and so on.

Burning hydrogen does have one problem with it, which is that it burns at high temperature and, as a result, does produce nitrous oxides. And so it's not totally without some pollutant potential to it.

I'm not familiar with all the technical details of the pros and cons of the aspect of hydrogen once you have it in your hand and can use it for a fuel. I'm not quite sure how to answer.

Senator EVANS. OK. I guess the question is whether it's—in looking at the future, we're spending hundreds of millions of dollars on some kinds of research and ultimately we'll spend billions on fusion in order to get us to a point where we have the potential of producing electricity or power, energy, from fusion; and a miniscule amount on the other side.

If we were to have that same or an equivalently large investment, are we as likely, less likely, or more likely, in other words, to get to the end result?

I guess we've got to pursue research. We've got to make some choices based on at least what we think has the reasonable chance of success. Are we balanced in the investments we're making?

Dr. TRIVELPIECE. It would be pure speculation on my part to try to answer the question specifically as you posed it. But the thing I am not aware of is, anybody presenting unsolicited proposals for an expended hydrogen program at the moment, if there are such proposals I'd be glad to take a look at them.

One of the things that has recently come to my attention is somewhere in the Midwest, and I forget which State now, but I read a report the other day on the fact that some gas wells out there are producing something like 20 to 40 percent hydrogen. It took them a while to find this out because the means by which they test the percentage of hydrogen, in fact used a chromatograph that used hydrogen as a carrier. And so it was some difficulty in proving what fraction this was.

But there may well be now certain gas wells that directly produce hydrogen in substantial quantities that may not have been noticed in the past because nobody did the measurements to confirm that that was the case.

The clue was that apparently concrete doesn't set very well in hydrogen. And some of the well casings were having difficulty with leaks, and the reason was that apparently hydrogen was preventing the concrete from setting up adequately.

Senator EVANS. This has been a very interesting, very useful session. I appreciate it very much and we will be back with the specific orientation toward fusion power, and we do have one public witness today. I understand Mr. Dean will not be able to be here during the day we have for fusion energy, so I'd like to call on Dr. Stephen O. Dean, president, Fusion Power Associates of Gaithersburg, MD, for his testimony.

Thank you very much, Dr. Trivelpiece.

STATEMENT OF DR. STEPHEN O. DEAN, PRESIDENT, FUSION POWER ASSOCIATES

Dr. DEAN. Thank you, Senator. My name is Dr. Stephen Dean. I'm president of Fusion Power Associates. Fusion Power Associates represents about 50 corporations, universities, and electric utilities that are interested in and participating in the development of fusion power.

I'd like to make a general remark. I'd like my testimony submitted for the record, and I'll just speak informally.

Senator **Evans**. Your full testimony will be submitted and added to the record.

Dr. **Dean**. The first thing I might remark is that perhaps I should endorse the comments of Senator Bumpers who expressed, quite eloquently, many of the opinions that I have about the Fusion Program.

But I am also concerned about energy in general. It's been remarked here several times this morning that there seems to be a trend going on for several years in which the amount of money on energy research and development and energy technologies has been systematically declining. And Dr. Trivelpiece said, "But energy research has been going up."

But even that, this year, as pointed out by Senator Bingaman, even the energy research part is going down in the 1986 requests.

So I think it's a matter of concern that we should be concerned about, that we are systemtically decreasing the amount of investment that we're making in our energy research and in our energy technologies. It's true that we don't seem to have an immediate energy crisis anymore, but it's also true that these techniques require many years for development before they can be used in a practical sense. And so if we wait until the crisis comes back to reinitiate some of these programs, we will already be too late to impact the economic problems that that next energy crisis will cause.

And I know that we have a budget deficit problem, and I am sympathetic to the fact that all Federal programs, especially civilian programs, have to be held down in terms of how fast they would like to go while we get ourselves out of this economic problem.

On the other hand, I think all of us have to try to balance the down side damage that could come to us as a country in our trade balance with other countries if we allow other countries, such as Japan and the Europeans, to develop some of these technologies while we don't.

I think that in fusion in particular, I know that much of the fusion effort is developed in Japanese industry. Hitachi and Toshiba are very strongly engaged in the technology development for fusion, and in this country almost none of our fusion research is done in industry.

So I think we have a problem that we need to pay attention to and do the best we can.

I have a chart on the first page of my written testimony in which I have tried to show in simple terms the fact that over the past decade or more, as we've invested in our research, we have systematically gotten closer and closer to our goal, and we are coming up at a point where several machines around the world can do the energy breakeven type demonstration.

Those demonstrations are expected before the end of the 1980's with high confidence. As Dr. Trivelpiece indicated, there is no plan at the moment as to when we will initiate the facilities that will allow us to proceed beyond the energy break even point and to the point where we can actually make substantial quantities of fusion power.

That will require some type of a new device such as an ignition test facility that Dr. Trivelpiece mentioned is in design, but it will also require other technologies such as materials technologies developments and nuclear component developments in order to make fusion power practical.

All of those things are technically possible. All of those things are going at a very slow pace these days because of the budget problems. Where last year the program was cut, the Senate, as you know, tried to limit the amount of that cut that was initiated in the House last year, but the administration took that cut as a signal that perhaps they could cut this year, which they did, so now we are faced with 2 years in a row possibly cuts, and once you get on a downward trend like that, the danger always is that those cuts might continue every year for the rest of the decade, in which case I think the program would be in serious jeopardy.

The administration is trying to strengthen international collaboration. I support that approach. It could potentially allow progress to proceed at a healthy pace, even if the budgets don't grow. If we can really get agreement to share the workload with other countries in a way that we're happy with, that we're not losing something.

The difficulty with that is that everybody wants to do the most important things, so it's hard to get everybody to divvy up and you work on this and I work on that, because if you're working on the most important thing, the other countries want to work on that, too.

So it's not going to be easy to get that international collaboration to be successful, but I support the attempts of the executive branch to do that.

I'm not here to try to argue for any big increases in the fusion budget. I think with what's going on in all the energy programs, we can't expect to get large increases in fusion if all the other energy programs are going down. We can't expect to get big increases in fusion as long as we're in a Federal budget deficit situation that we're in.

But I do hope that we can maintain the level of effort in the program and not allow this trend to continue to decrease the amount of resources we have available for the program.

In thinking about these problems, I've come up with one tentative proposal which I'd like to surface with you. I don't know if it's practical. But it seems to me that one of the problems here is that these programs are funded directly out of the Federal budget and the Federal Treasury.

If we could find some way of giving incentives to the private sector to invest in fusion, or if we could find some way to tax the eventual beneficiaries, which are primarily the electric utilities or the oil companies, with some small tax on electricity or some small tax on oil that could go into a trust fund for energy research and development, perhaps we could start to develop a stable base of funding for these kinds of programs that would be independent of the ups and downs of the Federal budgeting cycle.

I don't know if that's practical, but I do know that we're in a bad situation now where every year the amount of money available for energy research and technology development goes down. And let's face it; we're trying to impact an industry, an electric utility industry, which is trillion of dollars of investment in the 21st century. And so it's going to require a substantial amount of investment in research and development that's commensurate with the fact that we're dealing with trying to impact a trillion-dollar industry in the long term.

One of the problems is that the executive right now feels that the private sector will do these developments when the time comes, and I think that's not true, because the private sector is very highly motivated to invest in things that pay off within 5 or 10 years on profit, and they're not motivated to invest in things that take decades to develop. And so we have to find some way to keep developing these technologies on some kind of a time scale that's commensurate with the fact that this energy crisis will reemerge probably before the end of the century, and we ought to try to be ready for it when it comes.

So with that, I thank you for your time.

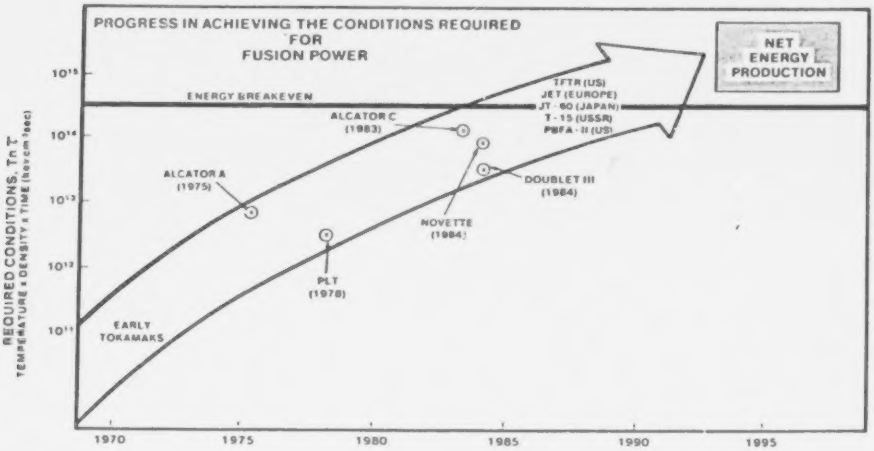
[The prepared statement of Dr. Dean follows:]

FUSION POWER ASSOCIATES
2 PROFESSIONAL DRIVE, SUITE 248 • GAITHERSBURG, MARYLAND 20879
(301) 258-0545

STATEMENT OF
DR. STEPHEN O. DEAN
PRESIDENT
FUSION POWER ASSOCIATES
TO THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
OF THE
SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
APRIL 30, 1985

Progress in achieving the combined conditions required for producing fusion power (high temperature, high density and adequate time duration) is continuing at an impressive rate, as shown in the figure below.

Unfortunately, while scientific progress has continued, there has been a weakening of government resolve to demonstrate the production of fusion power for practical purposes. Cuts in the program in FY 1985 and additional cuts proposed for FY 1986 would reduce program resources by about $80 million and



"TO TAKE FROM THE SEA AND TO IMITATE THE SUN"

have caused the Department of Energy to severely reduce the effort on our most ambitious projects: TFTR and MFTF-B. Many of us in the program believe that this will effectively transfer leadership of the world fusion effort to Europe and Japan. Opportunities for the participation of U.S. industry in fusion are significantly reduced.

In the face of policy restraints and budgetary reality, the DOE Office of Fusion Energy has devised a strategy that is reasonable under the circumstances. This strategy emphasizes pursuit in the near-term of several innovative ideas that are relatively inexpensive to test, strengthening of international collaboration and postponement of large hardware procurements. In describing the implementation of this strategy, however, I believe that the Office has underfunded efforts on systems analyses, long range planning and conceptual reactor design. A larger effort is needed to guide the research program and to assure the Congress and taxpayers that the fusion program is aimed at developing an attractive practical product.

I also urge you not to ignore the plight of the inertial confinement fusion program, which is included under DOE's weapons budget. The DOE has proposed to cut that program in half and to make it an "invisible" part of the weapons budget. I would consider it a national tragedy if DOE were allowed to decimate the inertial fusion program in this way.

The Board of Directors of Fusion Power Associates has approved a Policy Statement on fusion energy development which is attached.

FUSION POWER ASSOCIATES

BOARD OF DIRECTORS

POLICY STATEMENT

1985

The Board of Directors of Fusion Power Associates, on behalf of the association, urges that fusion power development be based upon the following:

RECOMMENDED POLICIES

- Research and development toward an economically–competitive fusion power system should receive high national and international priority.
- Engineering sciences, technology development, systems analyses and plasma sciences should all be considered essential elements in a balanced fusion effort.
- Timely commitments to necessary new and improved experimental facilities are needed to ensure continued program momentum and progress into the 1990's.

The above recommended policies are based upon the following:

FINDINGS AND RECOMMENDATIONS

- Fusion research, world-wide, continues to make outstanding progress.
- Concept improvements are emerging at a rapid rate, giving increasing confidence that an economically–competitive fusion power plant can be developed. Innovative ideas that reduce costs or accelerate knowledge should be expeditiously pursued in all aspects of the fusion program.
- It would be premature, at this stage, to judge which of the variety of magnetic and inertial fusion concepts will ultimately succeed commercially. This fact should not discourage use of the best available concepts in the design and construction of needed fusion test facilities.
- The fusion programs in the U.S., U.S.S.R., Europe and Japan have comparable accomplishments, facilities and momentum. The present rate of progress in the world program is based on capital investment commitments made in the 1970's. Progress will predictably diminish unless next step facilities are developed in a timely manner.
- International cooperative agreements have been a substantial factor in fusion progress and should be encouraged. Such agreements, however, are not an effective substitute for focused national efforts, needed national experimental facilities and subsequent engineering test devices.
- Governments should encourage and promote the full participation of industry in the planning, research and development as well as in engineering and operating aspects of fusion programs. If industry participates in the government - funded R & D programs now, industry will be better prepared to assess the commercial potential of fusion power in the future.
- Governments should foster innovation and optimize utilization of resources by encouraging and strengthening interrelationships among industry, laboratories and universities.
- Fusion - related programs in universities should be selectively strengthened and encouraged to ensure an adequate supply of engineers and physicists with knowledge in this field.
- The governments of the world have made a sustained investment in fusion research. The time has come to begin to capitalize on this investment by placing increased emphasis during the next decade on the engineering and systems design aspects of practical fusion energy systems.

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James A. Maniscalco, V.P., Programs and Membership

For further information, contact:
Fusion Power Associates
2 Professional Drive, Suite 248
Gaithersburg, Maryland 20879
(301) 258-0545

Senator EVANS. It seems to me that your last statement speaks very loudly as to perhaps one of the most fundamental problems we have today in this country, vis-a-vis our competition with our foreign neighbors.

Earlier, you said that in Japan it was corporate research being carried out in this field. They do apparently have the longer view and they've been very successful, because having the longer view and moving more consistently, they have essentially caught us in some areas, moved ahead in other areas, while our industry wrings its hands and wonders why the Government doesn't provide the money.

I understand Fusion Power Associates, from looking at the board of directors and the membership, has among its members the most distinguished and largest corporations in the country who would ultimately benefit markedly from a successful fusion program. They're the ones who would build the devices and have a very, very large stake in it.

It seems to me that it would be very useful for perhaps your outfit to collectively get together and make some proposals on joint efforts. How can we best bring everyone together; rather than just come to the Congress and ask for more money in terms of Federal research.

Dr. DEAN. Yes. That's a very good idea. In fact, two days from now, we actually have a meeting which is the third in a series of meetings that we're having with the Energy Department to try to do exactly that. We're developing industry proposals with the Department for industrial participation programs in fusion that would in part be paid by the Government, but would also in part be paid by industry, and we would like the Department to issue policy statements that would tell industry that they encourage industries to come up with their own ideas and to develop patent positions and to find some way of encouraging the industry to do more in fusion.

Frankly, the problem on the other side is that most of these industries take the path of least resistance to profit and they see a lot of business in the Defense Department. Most of our industries, in fact, work in Defense programs, too, and they're not sure how much it's worth to them as companies to spend a lot of their time thinking about working in the Fusion Program if the signals from the Government are that the program is going to be slowed down. They will look at other areas in which to invest their research dollars.

You need some incentives——

Senator EVANS. Or not invest research dollars at all.

Dr. DEAN. Yes; or in things that pay off very quickly.

Senator EVANS. Well, that's hardly research. At least, at best, that's applied research.

Dr. DEAN. That's right.

I think it may be unfortunate the industries don't have a more philanthropic orientation in this country, but that's not the way the country is set up, and so the Government does have to issue some kind of statement that they want industry to work in these areas or not, and that gives them some incentive at the top to do certain things that they might not otherwise do.

And so we need some—I think we need some leadership from the Department to say we encourage industry to work in this field.

Senator EVANS. I think that that's useful. And to the degree it can be coordinated or have some interrelationship with the basic research carried on by educational institutions or the Government, so much the better.

I'm not sure I would agree with the philanthropic idea of research insofar as corporations are concerned, because I think it does get back to whether someone is wise enough to have a longer view. I suspect those who have had the longer view in the past have been among the most successful of corporations, and those who've had the shorter view run into the cycles of up and down and wonder why their bottom line isn't as good as it ought to be.

Dr. DEAN. I think that's true, personally. You don't run into it too often anymore in private industry.

Senator EVANS. And I think that very likely, that's why we're having as much difficuly as we are in international competition today.

It seems to me that you're in a particularly good position in your responsibilities, working with the members of Fusion Associates to maybe restimulate some of that interest, and I'm delighted to hear of the meetings that are being held, and I hope that something useful will come out of them, and perhaps even in time for the hearing.

When do we have the fusion scheduled, or do we?

Dr. DEAN. I think it's May 9.

Senator EVANS. May 9? Do you anticipate that any information of value would come out of the meetings now being held by that time?

Dr. DEAN. It's possible. We're having a meeting, as I say, this week; and we're also having a meeting in California on May 9. So I think that—I don't know who the other witnesses are, but there may be someone from industry that will be testifying at that time that could tell you more about how we're doing on that.

Senator EVANS. If there's any progress or new direction or requests of us as to how we might assist in that process, it would be helpful.

Dr. DEAN. I'd be happy to send you a report on how we're doing within a few weeks.

Senator EVANS. Good.

Well, thank you very much. We have now arrived at 11 o'clock. The Senate does not allow us to sit beyond 2 hours past the session going in, so we have reached the end of this hearing. We appreciate very much, Dr. Dean, having you come and testify.

Dr. DEAN. Thanks very much.

[Whereupon, at 11 a.m., the hearing was recessed, subject to the call of the Chair.]

APPENDIX II

RESPONSES TO ADDITIONAL QUESTIONS

POST-HEARING QUESTIONS AND ANSWERS

FROM SENATOR JAMES A. McCLURE

FOR DR. TRIVELPIECE

Relating to

FY 1986 AUTHORIZATION HEARING

Before the

SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

APRIL 30, 1985

Question 1: Within the nuclear science portion of the Basic Energy Sciences budget, please provide a detailed breakdown of the funding associated with the Evaluated Nuclear Structure and Data File activities.

Answer: A detailed breakdown of the Basic Energy Sciences/Nuclear Sciences funding associated with the Evaluated Nuclear Structure and Decay File (ENSDF) activities follows:

ENSDF Funding
Operating Expenses
(B/A in Millions of Dollars)

	Appropriation FY 1985	Request FY 1986
Brookhaven National Lab	$1.5	$1.4
Idaho National Engineering Lab	0.1	0.1
Lawrence Berkeley Lab	0.4	0.4
Oak Ridge National Lab	0.3	0.3
Universities and Others	0.1	0.1
	$2.4	$2.3

Question 2a: How would you assess the U.S. capabilities with respect to supercomputer technology in comparison to progress being made in other countries, particularly in Japan?

A comparison of the status of U.S. supercomputer technology with that of other countries can be divided into several parts: hardware, software, applications and research on new approaches to very high performance computing. Before discussing each of these, it is important to clarify the definition of supercomputers. A supercomputer is the most powerful general purpose computer available for doing scientific computing.

Until recently, the U.S. has been the unquestioned leader in supercomputer technology. In fact, two U.S. companies, Cray Research Inc., and Control Data Corporation (CDC) dominate the world market in supercomputer systems.

During the past year, three Japanese companies have brought to the market the first foreign supercomputers. The Japanese machines appear to be very good in the areas of performance, hardware reliability, and surprisingly, software. Although performance measurement is difficult and depends upon workload, it appears that the latest machines from Cray Research have a performance advantage. However, the Japanese companies have done well with their initial offerings.

The outcome of competition between U.S. supercomputer companies and Japanese companies is, of course, difficult to predict. The U.S. companies, Cray Research and ETA Systems (a spin-off from CDC) are small while the Japanese companies, Fujitsu, Hitachi and NEC are large and vertically integrated. Vertical integration may be an important factor. For example, high performance integrated circuits are a key technology in supercomputer systems. Neither ETA nor Cray manufactures integrated circuits, whereas their Japanese competitors do. Both have had difficulty in obtaining the circuits they need from domestic sources. Of particular concern is the fact that Cray Research obtains a large fraction of their integrated circuits from Fujitsu, who may well turn out to be its largest foreign competitor in the marketplace. Obviously, the Government could solve this problem. It could specify that its next CRAY computer should be built entirely with U.S. components and the Government would be willing to pay the premium. We all believe that at some price U.S. companies would be willing to satisfy the Government's needs.

In supercomputer applications, the U.S. is the unquestioned leader. Government programs at the Department of Energy (DOE) and the National Science Foundation (NSF) for providing access to supercomputers for researchers in universities and other institutions will strengthen the U.S. capabilities substantially. Other countries are also moving aggressively in this area including Western Europe and Japan where a number of supercomputers are made available for university research.

Question 2b: Who is responsible for integrating the activities related to supercomputers among the various divisions of DOE?

Supercomputers are used primarily in two parts of DOE, Defense Programs and the Office of Energy Research (OER). Within the OER, there is an organization, the Scientific Computing Staff, that is responsible for managing all of OER's supercomputer related activities. These activities include providing supercomputer access to OER contractor and research in applied mathematics and computer science.

Supercomputer activities are coordinated across DOE organizations in several ways. The development of computer requirements and plans for major acquisitions for the Department's laboratories are the responsibility of the Office of ADP Management. An Ad Hoc Committee with representatives from all appropriate organizations within the Department meets periodically to discuss supercomputer issues and provides another coordination mechanism. In addition, there is coordination at the laboratory level through an organization of laboratory computer center directors entitled the Scientific Computing Information Exchange.

Question 3: In your testimony, you mention the contributions that high technology can make towards reducing U.S. vulnerability to critical and strategic imported materials. To what extent are the BES activities in this area coordinated with similar programs within the Advanced Research and Technology Division of DOE's Fossil Energy Programs, and also with a program currently being conducted within the Bureau of Mines on critical and strategic minerals at the Idaho National Engineering Laboratory?

Answer: The BES activities in materials research related to reducing the vulnerability to critical and strategic imported materials are coordinated with similar programs throughout the Federal government through various committee activities and through exchange of information among staff members and researchers. Within DOE, materials research is coordinated primarily through the activities of the Energy Materials Coordinating Committee (EMaCC), in which both BES and the Fossil Energy's Advanced Research and Technology Division participate. There are subcommittees which specifically focus on ceramics and steel research. Among different agencies, materials research is coordinated primarily by means of committees such as the Office of Science and Technology Policy Committee on Materials (COMAT) and the Interagency Materials Group (IMG). The BES program is further coordinated with the Bureau of Mines program on critical and strategic minerals at Idaho National Engineering Laboratory (INEL) through knowledge of their program, visits, and discussions with INEL managers who also manage BES research.

Question 4: Please provide for the record a summary of the activities planned in FY 1986 under the University Reactor Assistance Program. Please account for the difference in funding levels between FY 1985 and FY 1986. To what extent are the activities in this program dependent on NRC actions?

Answer: The main activity under this program is the procurement and fabrication of fuel elements for the university research reactors. The other major activity is the university reactor sharing program where reactor owning universities make their facilities available to faculty and students from other colleges and universities that do not have reactors. This program, through sharing, greatly extends the usefulness and efficiency of these research facilities.

In FY 1986 we anticipate producing reactor fuel for the University of Missouri at Columbia, MIT, Rhode Island Nuclear Science Center, University of Michigan and Ohio State University. This plate type fuel is produced by Babcock & Wilcox in Lynchburg, Va. We will also purchase from General Atomics Technology in San Diego, eight fuel rods for the Penn State TRIGA reactor.

In response to the NRC order for removal of excess unirradiated, High Enriched Uranium (HEU) fuel from non-power reactor facilities, we will be assisting in the transfer of small amounts of fuel from eight to ten university reactors to DOE facilities. We will also be assisting in the shipping of spent fuel from three to five university reactors to DOE. The funding of the base program in FY 1985 and 1986 is the same, $1,900,000.

The additional funding provided by Congress in FY 1985 was $2,000,000 for an assessment of the costs involved in converting university reactors from HEU to Low Enriched Uranium (LEU). Since the full amount was not required for this study, $1,000,000 was identified for management initiative savings. The other $1,000,000 was used for the study and to support the upgrade and conversion of two university reactors from HEU to LEU fuel.

NRC activities have a significant impact on the cost and efficiency of operating university research and training reactors. Each time additional regulations and requirements are imposed on these university reactors a higher cost burden is realized. Many of the small reactors, 100KW power level and below, do not have the staff and trained personnel to adequately respond to new regulations and reporting requirements while still meeting their teaching responsibilities. As a result many of these smaller facilities are closing down, a move that further reduces our overall national capability to train and educate professional manpower in the uses and applications of nuclear technology.

In terms of the proposed NRC rule for converting university reactors using HEU to LEU, we strongly believe it is unnecessary since it makes no allowances for the wide differences in these facilities. With the unirradiated HEU fuel that was once on campus now moved to DOE sites, there is no longer a valid reason for changing fuel. University reactors range in power level from 0.01 watt up to 10 megawatts. The highly radioactive fuel in those reactors with a 1MW and up power level cannot be construed as an attractive target for any group interested in HEU diversion. Steps to implement the rule for conversion to LEU will not be taken until a final position is taken by the NRC and we have time to review the requirements and their impact.

Question: The university enrollment in nuclear engineering disciplines is seeing a significant drop-off, which will ultimately translate into a shortage of well-trained nuclear engineers needed to staff nuclear power plants and related industries. Within the Engineering Research division of DOE, what plans are being made to emphasize nuclear engineering programs, in order to bolster interest and activities in such programs at the university level?

Answer: The Engineering Research activity plans to continue to emphasize research on a number of topics of special importance to the field of nuclear engineering as well as of use to other energy engineering specialties. These topics include, in particular, heat transfer, two phase flow, crack propagation in structures, and welding automation and control. Further, it is planned to conduct a majority of the individual research efforts on these topics at universities, thereby getting both well-trained engineers and important research results. However, DOE does not tell universities what to do nor do we simply fund good research programs unless the research is related to the DOE mission. I think the universities could give a more complete response on the issue of what is happening to the training of engineers.

POST-HEARING QUESTIONS AND ANSWERS
FROM SENATOR PETE V. DOMENICI
FOR DR. TRIVELPIECE

Relating to

FY 1986 AUTHORIZATION HEARING

Before the

SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

APRIL 30, 1985

Question 1: Back in the late 1970's we payed considerable attention to the health records of shipyard workers who had been exposed to nuclear reactors. Your office is managing an effort by Johns Hopkins to conduct a thorough epidemiological study of these workers. During Secretary Herrington's nomination hearing, we heard testimony to the effect that these studies were flawed.

An Advisory Group set up by you made some recommendations on how to improve the credibility of this program (attached). What has been done to date to implement these recommendations.

Answer: We are unaware of any basis for questioning the credibility of the Johns Hopkins study of nuclear shipyard workers. This particular study is being conducted by scientists who are highly regarded in the field of epidemiology and it has from its inception benefited from an independent peer review. In response to your question on the Health and Environmental Research Advisory Committee (HERAC), the HERAC identified four specific measures to improve the credibility of the epidemiologic research program; open solicitations for competitive research proposals, increased use of peer review mechanisms, increased collaboration between DOE epidemiologic research groups and university groups, and independent review and reanalysis of results by scientists outside the DOE program. To a large extent, these recommendations have been implemented.

The Office of Health and Environmental Research (OHER) policy of accepting unsolicited proposals for new research efforts from onsite laboratories, universities, and private organizations has been augmented by a new Special Research Grants Program. We now issue an annual competitive solicitation which should foster additional competition in the award of new grants. Currently, the OHER peer review process includes review of proposals by experts in the field prior to the award of each new contract and every three years thereafter. Peer reviewers often perform site visits as part of the evaluation process. Publication of research results in peer-refereed scientific journals is also an important factor.

The epidemiology program, as a whole, has been the subject of a comprehensive peer review in 1983 and a review by HERAC in 1984. Each individual epidemiologic study has its own independent Advisory Committee which meets at least once a year. These reviews and committees include several experts outside of the DOE system. In addition, we have recently initiated an outreach program to involve DOE/DOE contractor workers in the conduct and review of ongoing studies which affect them.

In order to increase collaboration between DOE and universities, funding is now provided for the participation of university scientists and training of students in several efforts including those conducted by Oak Ridge Associated Universities, Hanford Environmental Health Foundation/ Pacific Northwest Laboratories, Brookhaven National Laboratory, Lawrence Berkeley Laboratory, and Los Alamos National Laboratory. We have also acted on other recommendations made by the HERAC, which include assuming a leadership role in radiation and other energy-pollutant epidemiologic research, formulating clear objectives for the program, devoting more attention to the effects of other potentially toxic agents, providing continued strong support for the Radiation Effects Research Foundation in Japan, initiating research to address gaps in our scientific knowledge and exploring new approaches in human genetics.

Question 2: Your budget request calls for a reduction in the operating time for High Energy and Nuclear Physics (from 55% to 45% capacity). Can you provide for us the operating budgets for FY 1985 and FY 1986 for the affected facilities and their operating times?

Answer: The facility operations funding for DOE's high energy physics accelerator facilities in FY 1985 and FY 1986 is as follows: Fermi National Accelerator Laboratory, $84,915,000 and $87,700,000, respectively; Stanford Linear Accelerator Center, $50,835,000 and $52,000,000, respectively; and Brookhaven National Laboratory, $36,265,000 and $37,300,000, respectively. The actual operating times for FY 1985 and the operations planned for FY 1986 are shown in the accompanying table.

Seven existing accelerator facilities are operated by the Nuclear Physics program as national facilities; that is, they are open to a nationwide community of user scientists. Facility operations funding and utilization, expressed in terms of beam hours for research, for these facilities for FY 1985 and FY 1986 are shown in the accompanying tables.

HIGH ENERGY PHYSICS

FACILITY OPERATIONS

	FY 1985	FY 1986
FERMI NATIONAL ACCELERATOR LABORATORY	8 MO. FIXED TARGET 1 MO. COLLIDING BEAM	7 MO. $\bar{p}$ SOURCE TEST* 2 1/2 MO. COLLIDING BEAM TEST 1 MO. COLLIDING BEAM PHYSICS
STANFORD LINEAR ACCELERATOR CENTER		
PEP	6 MO. **	4 MO. **
SPEAR (HEP)	5 MO.	3 MO.
FIXED TARGET	2 MO.	2 MO. (MOSTLY 60 PPS)
SLC (PHYSICS)	---	---
SLC (COMMISSIONING)	---	6 1/2 MO.
	(MOSTLY 60 PPS)	(MOSTLY 10 PPS)
BROOKHAVEN NATIONAL LABORATORY		
AGS	7.5 MO.	7.5 MO.

* DOES NOT INVOLVE USE OF MAIN RING AND TEVATRON ACCELERATORS WHICH CANNOT OPERATE DURING THE LONG CONSTRUCTION SHUTDOWN IN FY 1986

** OPERATE SIMULTANEOUSLY; MONTHS NOT ADDITIVE

Nuclear Physics
National Accelerator Facilities
Facility Operations
(B/A in thousands of dollars)

Accelerator Facility	FY 1985	FY 1986
ANL--ATLAS	$ 2,795	$ 2,795
BNL--Double MP Tandem/AGS	1,500	3,550
LBL--Bevalac	17,360	17,780
LBL--88-Inch Cyclotron	2,110	2,150
LANL--LAMPF	39,245[1]	39,765
MIT--Bates	5,675	5,675
ORNL--Holifield	4,955	4,955
Nuclear Physics Total	$73,640	$76,670

[1] Includes $3,100,000 Defense Programs support of LAMPF operations

Nuclear Physics
National Accelerator Facilities
Beam Hours for Research

Accelerator Facility	FY 1985	FY 1986
ANL--ATLAS	2,600	3,500
BNL--Double MP Tandem	2,200	1,500
BNL--Tandem/AGS[1]	0	100
LBL--Bevalac	3,500	3,300
LBL--88-Inch Cyclotron	3,500	3,200
LANL--LAMPF	3,000	2,400
MIT--Bates	2,740	2,100
ORNL--Holifield	4,000	3,500
Total	21,540	19,600

[1] First heavy ion operation in FY 1986

Question 3: Could you summarize for the record where we are to date on the Superconducting Super Collider in terms of how we are going to pay for it?

Answer: The Department has to date made no commitment to proceed with construction of Superconducting Super Collider (SSC) and therefore has no specific funding plans or schedule. It is clear that a project of this magnitude will require substantial incremental funding for the high energy physics program during its construction period. If DOE decides to proceed with SSC construction, the Department, at the appropriate time, will develop plans for SSC funding which will be consistent with the overall budget situation of the Nation and competing priorities for funds.

Question 4: Given the difficulties in operating our existing facilities what can be done to assure we do not kill a generation of scientists by closing down todays machines in order to build the SSC?

Answer: In order to avoid the potential detrimental impact to which you refer, we expect to maintain effective operation of our present facilities and those nearing completion during the period prior to operation of Superconducting Super Collider (SSC). We would plan to phase out some of these facilities late in the SSC construction period as effort is required on SSC detectors and preparations for operation of SSC. However, we have no plans to prematurely terminate present facilities and cause serious disruption to high energy physics manpower. In this way, we hope to maintain a roughly constant overall level of effort and achieve a smooth transition to SSC.

Question 5: Could you provide for the Record, the status of the old Post-Doctoral fellowship program? In terms of your cost-shared fellowship program, could you provide us with some details as to who is participating?

Answer: Our records show that there were 335 Post-Doctoral Appointees at DOE Labs in FY 1985. These appointments were primarily in the fields of chemistry, physics and the biological and environmental sciences. In most cases funding was provided by the program areas where they were working. This year, under the cost-shared fellowship program with industry, there are twelve appointments at seven DOE Laboratories. The participants are as follows:

Department of Energy
DOE-INDUSTRY TECHNOLOGY EXCHANGE RESEARCH PROGRAM
FY 1985 APPOINTMENTS

Participating Laboratory	Company/Participant	Research Project
Argonne National Laboratory Argonne, IL	Borg-Warner Ingersoll Research Center DesPlaines, IL Clarence Albertson	Development of coatings and surface treatments
	Gas Research Institute Chicago, IL Michael M. Mamoun	Study of mechanical and chemical properties in polyethylene piping
Brookhaven National Laboratory Upton, LI, NY	Bicron Corp Newbury, Ohio Roderick Dayton	Develop improved crystal processing
	INSPEX-Hamamatsu Waltham, MA Eiji Inuzaka	Develop medical imaging device for radiopharmaceuticals
Lawrence Berkeley Laboratory Berkeley, CA	Ayres Sowell Associates Fullerton, CA Ayres Sowell	Develop computer programs to simulate energy use and performance in buildings
Los Alamos National Laboratory Los Alamos, NM	St. Jude Medical Inc. St. Paul, MN Dean Brukn-Ding	Adapt phase inversion techniques for making flexible foams
	Mesa Diagnostics Los Alamos, NM Stephen Young	Identification of toxins with DNA probes using multiparameter light scattering technology
Oak Ridge National Laboratory Oak Ridge, TN	CPC International Inc. Summit-Argo, IL William Reed	Genetics and culturing of anaerobes and the application of bioreactors
Pacific Northwest Laboratory Seattle, WA	Boeing Aerospace Kent, WA James Nelson	Non-destructive testing and acoustic emission signal processing and software development
	Boise Cascade Wallula, WA Andrea Slayton	Research on metals corrosion in pulp and paper industry
Sandia National Laboratory Livermore, CA	John Deere & Company Woodbridge, NJ Philip Dimpelfield	Study fluid mechanics in operating engines using laser diagnostics
	Computer Genetics Co. Wakefield, NJ Richard Guthrie	Develop spectroscopic system temperature measurements in industrial furnaces

POST-HEARING QUESTIONS AND ANSWERS
FROM SENATOR J. BENNETT JOHNSTON
FOR DR. TRIVELPIECE
Relating to
FY 1986 AUTHORIZATION HEARING
Before the
SENATE ENERGY AND NATURAL RESOURCES COMMITTEE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
APRIL 30, 1985

Question: One of the important issues in the budget you are discussing is the issue of how we are going to fund the facilities for fundamental scientific research that you are planning - in particular, the Superconducting Super Collider (SSC). I understand that this accelerator will cost more than twice the original $3 billion cost estimate.

Answer: The cost estimate for the Superconducting Super Collider (SSC) has not increased from the original estimate. Let me try to clarify the meaning of the various cost figures which are sometimes quoted with regard to SSC. An extensive Reference Designs Study, in the spring of 1984, by some 150 scientists and engineers resulted in a preliminary cost estimate of $3 billion (FY 1984 dollars) for the construction of the SSC facility. Results of the R&D program carried out since then confirm the technical assumptions of the Reference Designs Study and lend substantial support that the SSC can be built within this cost estimate, and possibly for less. Other costs associated with the SSC for a full complement of detectors, R&D effort, and pre-operating costs are estimated to add almost $1 billion (FY 1984 dollars), bringing the total costs to about $4 billion. With the addition of inflation over an assumed six to seven year construction period, this total becomes $6 billion in then year dollars. Thus, the estimated cost of the construction project has not changed, but the units used to express the costs (FY 1984 dollars or then-year dollars) and the scope of what is included in the quoted cost can vary.

Question: Outside of the defense budget, I don't know where the Federal government is engaged in a construction project of this magnitude. Certainly not in energy technology. Is there a parallel in anything we are doing now this magnitude of Federal support for a project with only civilian uses?

Answer: I might note that the cost of the original construction project for the Fermi National Accelerator Laboratory (Fermilab) and associated capital equipment would be approximately $0.8 billion in FY 1984 dollars. The other capital investments at that facility to date bring the total investment in Fermilab to about $1.5 billion in FY 1984 dollars, about 40% of the $4 billion estimate for the SSC. So within the high energy physics program there is a precedent of a facility that is very large although smaller than Superconducting Super Collider (SSC). Within the Department there is no effort of parallel magnitude today. I am not an expert on programs of other agencies, but I can recall projects such as the NASA space station initiative (projected cost of approximately $8 billion in FY 1984 dollars), which is expected to require nine years to complete.

Question: I also understand that the operating cost of the SSC will be a significant fraction of the current budget for all of High-Energy Physics. The issue therefore is how you are going to manage to fit this kind of very big project into a budget that very probably cannot increase. Are you counting on an increase in the High Energy Physics budget to fund the SSC or do you intend to build the SSC within a constant budget? If you count on an increase, how much will it have to be in absolute and in percentage terms?

Answer: Since the Department has not yet made a commitment to proceed with construction of the SSC, specific funding projections have not been developed. However, it is clear that Superconducting Super Collider (SSC) construction would require a temporary, substantial increase in the high energy physics budget during the six-year construction period; over this time period an average increase in the range of $0.5 - 0.6 billion (FY 1984 dollars) per year would be required. This can be compared to the FY 1985 appropriation for high energy physics of $542 million. Based on very preliminary estimates we believe that operation of the SSC after completion of construction could be accommodated within a total high energy physics budget level near that of the FY 1985 level of effort by shutting down older high energy physics facilities no longer capable of doing forefront research.

Question: Won't the SSC be subject to the same kind of pressure the deficit has put on all discretionary portions of the civilian Federal budget? How will the SSC be different?

Answer: Investment in forefront basic research is vital to the future well being and strength of this country. Basic research underlies the technologies that contribute to our modern prosperity. There is necessarily a time lag in this connection. Current technologies were made possible by research done in the past, and there is every reason to expect that the results of current forefront basic research will continue to pay off handsomely in the future. The Superconducting Super Collider (SSC) is important to maintaining a forefront and world-competitive U.S. high energy physics program, an important component of the Nation's basic research effort. If we decide to proceed with the SSC, it will obviously have to be planned and funded within the constraints of the Nation's overall budget situation. It is a challenge, and I believe essential for the long-term health and vitality of the Nation, to develop ways to achieve important scientific and technological goals such as SSC even with restrained budgets.

Question: How do you explain (or how would you advise that I explain) to a Senator who would like to see the coal technology developed that coal funding should be sacrified to build something like the SSC - which is aimed at studying states of matter that only existed in the first few moments of the universe?

Answer: If the Nation is to remain competitive and healthy for the long term, balance must be sought such that all links in the research and development chain remain healthy. The needs and promise of each area of research and development should be separately examined. It is important to ensure that critical initiatives of highest priority to the Nation be pursued and that efforts in one area do not cause damaging disruptions in other important areas.

Question: In order to provide the Committee with a clearer picture of this issue, please describe the Department's current plans for the Superconducting Super Collider; that is, how much has been spent to date on the SSC including the amount in your current budget request?

Answer: Accelerator R&D specifically related to the Superconducting Super Collider has been funded at the $20 million level for FY 1984, FY 1985, and FY 1986, for a total of about $60 million through FY 1986.

Question: What is your current total estimated cost to design and construct the project?

Answer: The current estimate for the cost to design and construct the Superconducting Super Collider project based on the 1984 Reference Designs Study, is $3 billion in FY 1984 dollars, excluding R&D, detectors, and preoperational costs.

Question: What is the estimated operating cost of the project?

Answer: Since the Department has not yet committed to proceed with construction of the SSC and design studies have not been completed, definitive estimates of these costs have not been developed. A preliminary estimate indicates that annual costs after routine operations begin could be about $250 million (FY 1984 dollars) per year. This would include operating costs and the annual capital costs for detectors, computers, accelerator improvements, and general plant projects.

Question: Provide the Committee with your best current year-by-year estimate of the cost to design, construct and operate the SSC through its first full year of operation. Show when the decision to construct the facility will be made. Show also the projected budget for all of high energy physics for each of these years.

Answer: The Department has made no commitment to proceed with construction of the Superconducting Super Collider (SSC) and no formal construction cost profile or schedule has been developed by the Department. R&D studies currently being pursued will provide technical and cost data on which the Department can reach an informed decision on whether to seek approval to proceed with the SSC. Until a decision on SSC is reached, detailed projections for the overall high energy physics program will not be available.

Question: Do you expect to propose reduced expenditures for construction and upgrading of other High Energy Physics facilities during this time? Which ones?

Answer: Yes, in fact, we have already done so. High energy physics construction funding has been reduced substantially from $114 million in FY 1985 to $55.5 million in FY 1986 as the Stanford Linear Collider (SLC) and Tevatron near completion. Work on the Colliding Beam Accelerator at Brookhaven National Laboratory was stopped in FY 1984 in order to permit concentration of resources on the R&D leading toward the Superconducting Super Collider (SSC). No large new construction projects are being contemplated beyond Tevatron I and SLC prior to completion of SSC, under the assumption that there will be no major delays in achieving the capabilities of the SSC.

Question: Do you expect to propose reduced operating funds to any programs within High-Energy Physics? Which ones?

Answer: Should we decide to proceed with construction of the Superconducting Super Collider (SSC), then toward the end of the projected construction period, as existing facilities mature and become less-than-forefront, their operation would be cut back and phased out. This would permit the redirection of resources for work on SSC detectors in the early 1990's and subsequently for bringing the SSC into operation. It is premature to try to identify today which facilities would be curtailed and when--this will depend on progress of the SSC as well as the evolution of the science and related technologies.

Question: In layman's terms how would you explain the sort of science the SSC intended to probe? For example, what indications are there that interesting physics can be done in the specific energy range of the SSC? Is this issue controversial in the scientific community? If so, describe the controversy and your own view of the merits of the issues.

Answer: The Superconducting Super Collider (SSC) is designed to answer some of the deepest questions of physics. It may point the way to one of the most basic goals of physics: the discovery of a correct Grand Unified Theory of fundamental forces. Although spectacular progress has been made in high energy physics in recent years, many fundamental questions remain. Based on our present understanding, new phenomena are expected in the TeV mass range which will be opened for exploration by the SSC. I am not aware of any controversy. There are, of course, many different predictions as to what will be found. The exact form these phenomena will take is open--there are many possibilities. The correct possibility must be found by experiment. In addition, if history is any guide, the SSC will produce discoveries of a totally unexpected nature, leading to new directions of scientific inquiry.

Question: It is often helpful to be able to point to "spinoffs" from basic scientific research that benefit in a tangible and direct way those who paid for the research. How would you make the case for spinoffs from the SSC project?

Answer: Since spinoffs of technology from high energy physics research are not planned in advance and develop from the ongoing work. It is not possible to give a specific forecast ahead of time of the spinoffs which will result from the SSC efforts. There are, however, already several areas where some technology spinoffs are indicated from the SSC R&D program. As a result of work carried out in a university R&D effort, together with development activities in superconducting cable supported by the SSC, the capability of U.S. superconducting wire manufacturers to produce high current density niobium-titanium wire has greatly improved. The average current density of industrially produced NbTi wire was about 1900 Amperes/square milimeter for the Fermilab Energy Saver/Tevatron I magnets. It is now typically 2800 Amperes/square milimeter and production runs exhibiting 3000 Amperes/square milimeters have been made. This has made the U.S. manufacturers more competitive on world markets and contributed to the performance of a variety of superconducting magnet applications outside of high energy physics, including magnetic resonance imaging. The work done on superferric magnet technology, one of two main alternatives considered for the SSC, looks as though it has application in making improved magnets for magnetic resonance imaging systems now coming into use as a medical diagnostic tool.

Another area of anticipated spinoff is further development of very high speed instrumentation modules compatible with the FASTBUS instrumentation standard. This has been a traditionally fertile area of spinoffs in the past and the SSC detector and machine control requirements indicate that this trend will continue.

POST-HEARING QUESTIONS AND ANSWERS
FROM SENATOR WENDELL H. FORD
FOR DR. TRIVELPIECE

Relating to

FY 1986 AUTHORIZATION HEARING

Before the

SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

APRIL 30, 1985

Question 1: On page 25 of your statement you say that one of the accomplishments of the Basic Energy Program has been "Discovery of a new catalytic system for the direct conversion of carbon monoxide and water to methanol. This new catalyst makes it possible to make the conversion using water rather than the more expensive hydrogen and at pressures and temperatures much lower than current practice allows."

Could this catalytic system be used for the more economic conversion of coal to methanol and how important is this discovery for that purpose?

Might this system expedite the widespread availability of coal-derived methanol?

Answer: The new catalytic system that has been discovered at Argonne on a small, laboratory scale allows synthesis gas, made up in any ratio of carbon monoxide to hydrogen, to be used to produce methanol, since water serves as the hydrogen source rather than hydrogen itself. The discovery at this stage is scientific in nature and its practical utility is yet to be determined. If it proves out, it would provide two clear advantages in using synthesis gas derived from gasifying coal. First, a costly intermediate process to convert carbon monoxide and water to hydrogen and carbon dioxide can be avoided and second, the direct conversion of carbon monoxide and water to methanol gives a higher yield of methanol. These are the reasons to hope that this system will be the basis for more economic converting of coal to methanol and thereby expedite the widespread availability coal-derived methanol. Research continues in order to obtain a better understanding of the chemistry involved and thus provide the technical knowledge needed in evaluation of the system's practicality.

Question 2: In P.L. 98-620 enacted November 8, 1984, the laws governing the patent rights of scientists conducting their research with federal funds were amended to give the enhanced rights to small businesses and nonprofit institutions. In essence, the Government funds the research but the private contractor or researcher gets the patent.

Are you familiar with this statute?

What effect, if any, do you anticipate these amendments may have on the competition for federal funding for research?

Answer: I am familiar with the patent legislation. These amendments could possibly increase the interest of potential competitive bidders particularly in federally-funded applied research areas.

Question 3: I understand that the Commerce Department has just issued a notice of proposed regulations to implement this Act. Do you see any possibility that expansion of the researcher's patent rights might make their research work more oriented toward practical applications and less toward fundamental research.

Would you provide for the Record your comments on any problems you envision in carrying out your research programs and complying with these recently enacted amendments?

Answer: It is possible that the incentives provided by patent rights could militate toward a more practical or commercial orientation of research. DOE therefore, along with encouraging technology transfer, intends to maintain strong management oversight of laboratory research work to ensure that it is properly directed in accordance with agency missions. In so doing, we will seek to ensure that "basic research" remains a viable and balanced component of Federal R&D expenditures.

DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS—FISCAL YEAR 1986

(Fusion Energy Programs)

THURSDAY, MAY 9, 1985

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:40 a.m., in room SD-366, Dirksen Office Building, Hon. Pete V. Domenici presiding.

Present: Senators Domenici and Evans.

Also present: Paul Gilman, professional staff member; Benjamin S. Cooper, professional staff member for the minority; and James T. Bruce, counsel for the minority.

OPENING STATEMENT OF HON. DANIEL J. EVANS, A U.S. SENATOR FROM THE STATE OF WASHINGTON

Senator EVANS. This hearing will please come to order.

Let me first apologize for Chairman Domenici. As you might guess, today is the day we have been looking forward to, I hope, when at least we will have a chance to vote on the final budget deficit-reduction package, and he is a key member of that effort, and so he is over in the leader's office.

The first witness today on the oversight hearings on the Department of Energy's Research and Development Program, with special emphasis on the Fusion Research Program, is Hon. Alvin Trivelpiece, Director of the Office of Energy Research, U.S. Department of Energy.

Dr. Trivelpiece.

STATEMENT OF DR. ALVIN W. TRIVELPIECE, DIRECTOR, OFFICE OF ENERGY RESEARCH, DEPARTMENT OF ENERGY

Dr. TRIVELPIECE. Mr. Chairman, good morning. It is a pleasure to be here. I hope my prepared statement will be made a part of the record.

Senator EVANS. Your full statement will be made part of the record.

Dr. TRIVELPIECE. As you recall at the hearing a little over a week ago, the subject of fusion came up from Senator Bumpers, and I almost had the feeling I gave my complete testimony on this subject at that hearing. So, I will be brief this morning and just try to set the stage with a few opening remarks.

Since the last hearing on fusion before this committee, the budget for fusion was cut by $43 million through action of the Congress last year. That was a difficult adjustment to have to accommodate. We did that by slowing down some of the technology activities and slowing down some of the construction things and delaying a few other activities.

This year as part of the administration's deficit reduction activities, the Fusion Program was held at a freeze level, minus 10 percent, which amounts to essentially another $40 million reduction. The requested funds in fiscal year 1986 are $390 million.

The additional reduction, obviously, is slightly more difficult to try to accommodate and we are doing this in a way which we hope will maintain some degree of balance and address the critical issues that the program needs to have focused on.

We find in all of this a certain amount of irony in that earlier on in the Fusion Program when there were some struggles over trying to increase the budgets, one of the principal questions was, "Will fusion work?" I think that the point has been reached in which it can clearly be stated that, yes, it will, but we now find ourselves in a period in which the urgency to get on with the job seems to be less, as a result, in part, of some of the global conditions having to do with energy supplies, the price of oil, the price of uranium ore, and general budgetary difficulties.

The program has met its goal. It has generally done excellent work. Milestones have been met and, in addition, it has been a major contributor to the development of, and training of, scientists and engineers that are needed for many of the Nation's other technical programs.

The reduction that has been imposed on the program is consistent with some of the reductions that were made in other elements of the Department, so I feel that this activity has had a fair hearing within the Department. Secretary Hodel, who helped formulate this budget, had an adequate opportunity to understand the pros and cons of this relative to other elements of the Department and we were treated fairly in that regard.

That concludes my opening remarks. I would be glad to answer any questions.

[The prepared statement of Dr. Trivelpiece follows:]

Statement of Alvin W. Trivelpiece

Director of Energy Research

Department of Energy

before the

Subcommittee on Energy Research and Development

of the

Senate Energy and Natural Resources Committee

May 9, 1985

Mr. Chairman and Members of the Subcommittee:

I am pleased to appear before you today to discuss the FY 1986 budget request for the Magnetic Fusion Energy (MFE) program. This budget request reflects the goal and strategies set forth in the Fourth National Energy Policy Plan (NEPP-IV). NEPP-IV notes the importance of Federal energy R&D programs aimed at developing new and alternative energy resources by providing scientific and engineering knowledge for further development by the private sector. The ultimate goal is to foster an adequate supply of energy at reasonable costs.

In accord with NEPP policy, the Magnetic Fusion Energy program is developing the science and technology base that will make it possible to determine what role fusion could play in a mixed energy resource system. Although it may take decades to develop significant new energy sources that will contribute to a more flexible energy supply system, it is important, from an economic, social and defense perspective, to continue to work steadily toward that goal.

PROGRAM STRATEGY

The Fusion program's strategy is to maintain a broad R&D program with emphasis on establishing the basic elements, including components and subsystems, of the science and engineering technology required for fusion. This strategy will allow us to explore the feasibility and potential usefulness of a range of fusion device options. In doing so, the program is designed to ensure that sufficient information is available to allow private industry to make informed decisions on whether to pursue fusion development in the future. The schedule for completion of magnetic fusion energy development is directly related to the technical, political and economic uncertainties of the world energy supply that are likely to exist for several decades.

In addition to R&D supported in the U.S., there are important international dimensions to fusion research. Because of the global benefit of fusion applications, the commonality of goals, the scale and difficulty of the research and the lack of competitive commercial pressures, international collaboration in fusion energy development is particularly appropriate. The United States Fusion program has had a successful history of international cooperation and collaboration; and we will continue to seek out mutually advantageous opportunities for collaboration that will minimize duplication and allow us to achieve our goal more effectively.

The U.S. Fusion program is pursuing three objectives, those of science, technology, and technology transfer, that must be achieved to meet the program goal. The science objective is to be able to predict the behavior of high-temperature plasmas confined in different magnetic fusion configurations. There are several magnetic confinement systems that could be developed into energy-producing devices. An ability to predict how the plasma will behave is particularly important because all of these systems cannot be fully developed in parallel. Only through our ability to predict plasma behavior will we be able to make informed choices about the best direction for fusion development.

The technology objective is to develop unique fusion components that can operate under conditions relevant to fusion energy. Wherever possible, the program will draw on technological developments that are already available elsewhere and will support research and development on those components that are unique to fusion or beyond the industrial state-of-the-art. Such unique components exist in the areas of magnetics, plasma heating, energy removal, fuel production, and materials.

The third objective, technology transfer, is to provide knowledge and experience in order to identify a range of options for private sector investment and commercial development of fusion. This objective is initially pursued by having the industrial participants apply their expertise to the development of fusion components and subsystems. Through this direct participation, industry will continue to gain experience with the unique aspects of fusion. Technology transfer provides a stimulus to U.S. technology growth as well as providing a training environment for industrial scientists and engineers.

TECHNICAL ISSUES

With this strategy in place, the program can move ahead to address the four key technical issues that must be resolved if fusion power is to be developed successfully. The first of these involves magnetic confinement systems. It is important to explore an appropriate range of possibilities for magnetic confinement to ensure selection of the most desirable fusion reactor system in the next century. The second technical issue is to understand the properties of burning plasmas. A fusion plasma is expected to burn when the heat released within the plasma by the fusion reaction is sufficient to maintain the plasma temperature in the face of heat loss from the system. The conditions required for ignition will be explored in the Tokamak Fusion Test Reactor (TFTR) at Princeton during the latter part of the 1980's. Following this achievement, at least one burning plasma must be produced and studied to complete the scientific base. The third technical issue is materials for fusion systems. The ultimate economics and environmental acceptability of a fusion system will depend on the development of various materials that are required. The last issue is nuclear technology for fusion systems. This includes developing a fusion "blanket" that must perform several functions including converting the energy released by a fusion reaction into useful energy, creating part of the fuel for the reactor and allowing recovery of this fuel, as well as shielding critical components from radiation. To resolve this issue, it is necessary to develop technical options in order to be able to optimize the economic, safety, and environmental performance of a fusion reactor. The energy recovery system, or blanket, will have to be tested in a fusion environment.

In addressing these issues, sufficient breadth must be maintained to ensure that adequate information is available to allow informed decisions on the desirability and schedule of the ultimate commercial applications of fusion energy. Since it is impossible at this time to predict either the economic conditions affecting such a decision or its schedule, it is premature to focus on developing a specific reactor type. Instead, the program will systematically study and resolve the basic issues of science and technology that affect the feasibility of a range of options.

To expand the science and technology base it is necessary to develop a thorough understanding of the scientific principles underlying the confinement of plasmas in magnetic fields. There are two principal approaches to magnetically confining a plasma: the toroidal and linear concepts. A number of variations are possible within each of these two categories. Since the basic scientific phenomena which must be investigated experimentally change according to the shape of the magnetic configuration, a variety of concepts will be investigated to complete the science base. By studying these related concepts, a better understanding of plasma behavior will be achieved than if only one concept were studied. Further, it is expected that this broad approach will most readily lead to improvements in present devices and the development of superior magnetic geometries for practical application in the future. This research includes work on toroidal configurations including tokamaks, reversed field pinches, stellarators, and compact toroids, as well as linear configurations called tandem mirrors.

SCIENTIFIC AND TECHNICAL PROGRESS

The Magnetic Fusion program made substantial scientific and technical progress in 1984. Among the confinement concepts, the tokamak has achieved the best plasma conditions in terms of confinement time, temperature and density. Several of the program's tokamak facilities, including the Princeton Large Torus (PLT), Doublet III (D-III) at GA Technologies (GA) in San Diego, Impurity Study Experiment-B (ISX-B) at Oak Ridge National Laboratory (ORNL), the Princeton Beta Experiment (PBX), and Alcator C at the Massachusetts Institute of Technology (MIT), have been able to explore different and complementary aspects of plasma behavior at near reactor-level plasma conditions.

In addition, the Tokamak Fusion Test Reactor (TFTR) has begun its experimental research phase to investigate the physics that must be mastered in order to ignite a plasma. Experiments supported for FY 1986 in TFTR should allow study of fusion plasma behavior at energy breakeven temperature and density conditions. The energy breakeven point, at which the energy produced by a fusion plasma is equal to that required to sustain the plasma, is an important milestone for magnetic fusion.

A criterion that must be satisfied to reach this breakeven point is that the product of plasma density, energy confinement time, and temperature must be greater than a certain minimum value. This past year, scientists at GA and at the Princeton Plasma Physics Laboratory (PPPL) made significant progress toward achieving these threshold plasma conditions. At GA, a team of Japanese scientists working on the Doublet III tokamak, under a joint funding agreement between the Department of Energy (DOE) and the Japanese Atomic Energy Research Institute (JAERI), realized a world record density-temperature-confinement product which was about 30 percent of that needed for energy breakeven. In addition, initial operation of TFTR without any auxiliary heating achieved an encouraging energy confinement time of 0.38 seconds at high plasma currents. These results increase our confidence that TFTR will reach fusion energy breakeven conditions when it is operated with full auxiliary heating and a deuterium-tritium gas mixture in 1988.

Progress also has been made in mirror research. The Tandem Mirror Experiment at Lawrence Livermore National Laboratory (LLNL) has continued to establish the basic scientific principles of confining plasmas with combined electric and magnetic fields. In addition, a second tandem mirror research facility called TARA, has begun operation at MIT. A major 1984 achievement in research on open-ended, mirror devices was the direct experimental verification of a theoretical concept called the "thermal barrier". Thermal barriers play a key role in stopping plasma from leaking out the ends of cylindrical-shaped tandem mirror machines. Proof of the barriers' existence increases the likelihood that reactor-grade plasmas can be confined in large mirror devices.

In the technology area, progress has been equally encouraging. New, more effective beam technology, used to heat fusion plasmas, has been tested successfully. These new beam sources will improve the capability of our experiments to investigate high-temperature plasmas because the sources can operate for longer times at higher powers. In 1984, scientists using high intensity neutral particle beams to heat fusion plasmas successfully tested the most powerful neutral particle beam plasma heating system to date, achieving pulse lengths up to 30 seconds long. These beams should be sufficient for obtaining the energy breakeven plasmas expected in TFTR over the next few years. A second new heating source, high-frequency, high-power electromagnetic waves generated by a newly developed gyrotron tube, have been shown to preferentially heat the electrons in a fusion plasma, thus providing a promising additional mechanism for plasma heating and control. Extrapolation of results from successful 1984 plasma heating tests indicate that it should be physically possible to build a reactor size plasma heating system with gyrotron technology.

The plasmas in fusion machines need to be refueled as fuel is burned up or particles are lost from the plasma. One of the most promising approaches to refueling is use of pellet fuel injectors. These injectors have provided the key to obtaining stable, well-confined plasmas in current experiments such as Alcator C and Doublet III. In 1984, a pneumatic type injector, which uses a compressed gas mechanism to fire frozen hydrogen pellets at 2 kilometers per second, enabled world record plasma conditions to be reached in several fusion experiments. In addition, a centrifugal type injector accelerated single pellets to almost 1 kilometer per second, and indications are that this could be done on the repetitive basis needed for a fusion reactor. These results mean we have now developed a capability to fire fuel pellets deep into reactor-grade plasmas.

An important element of the Magnetic Fusion program is to provide a technology base for large-scale superconducting magnet systems, which exhibit virtually zero electrical resistance at cryogenic temperatures. World-wide recognition of this technology need has resulted in a major international cooperative program through the International Energy Agency (IEA), involving the U.S., Japan, Switzerland, and Euratom. The first two large superconducting coils developed under this international collaboration have been energized in the International Fusion Superconducting Magnetic Test Facility at ORNL. In late 1984, a test with the two foreign magnets and one U.S. magnet provided an integrated checkout of subsystems as well as an initial test of interactive magnetic and structural stress effects on large superconducting magnets. These results will be used to guide a full six-magnet test schedule to begin in late 1985. Finally, new approaches to develop materials that will not become as radioactive as conventional materials for use in fusion systems have been developed.

In the area of international cooperation during the past year, cooperation with the European Community, Japan and the Soviet Union continued to play an important role in the U.S. Magnetic Fusion program. Areas of cooperation include sharing research data, joint planning of selected research programs, and joint support for major scientific and technological projects.

With the endorsement of the heads of state meeting at the summit of industrialized nations, three panels initiated in 1984 began to: 1) develop potential opportunities for collaboration through joint support of large scale projects; 2) identify increased near-term collaborative activities in physics, technology and concept development; and 3) evaluate opportunities for reducing administrative barriers to collaboration.

In 1984, the Department of Energy signed agreements with the Japanese Atomic Energy Research Institute to test equipment in the U.S. for improving tritium processing systems, and to evaluate in Japan the effects of high energy neutrons on materials. The U.S. successfully tested a key piece of equipment for the European Community's large fusion facility, the Joint European Torus (JET), and also began to work with Spain on advanced stellarator development. Technical agreement was reached on three new agreements with the International Energy Agency in the areas of large tokamak facility operations, stellarator experiments and impurity control in fusion plasmas.

FY 1986 MAGNETIC FUSION ENERGY BUDGET REQUEST

The FY 1986 budget request for Magnetic Fusion Energy is $390.0 million. The request includes $346.4 million for Operating Expenses, $30.4 million for Capital Equipment, and $13.2 million for Construction (Table 1).

This budget request will provide support for scientific experiments necessary to understand the behavior of fusion plasmas confined in magnetic fields. In addition, the supporting technology development needed to carry out the scientific program and to advance the state-of-the-art in those areas of science and technology required to realize the unique features of fusion as an energy source will be funded. Support also will be provided to continue to execute international agreements.

The budget request for FY 1986 reflects a significant shift in the program balance. The near-term scientific and technological output of the program will be emphasized while continuing to pursue the long-range goal of developing fusion at a pace consistent with our national

Table 1
Magnetic Fusion Energy
Budget Authority
($ in millions)

	FY 1985 Estimate	FY 1986 Request
Operating Expenses	$374.3	$346.4
Capital Equipment	30.2	30.4
Construction	32.5	13.2
Total	$437.0	$390.0

energy needs. The near-term program achievements also will continue to include the production of well-trained scientists and engineers and contribution of advanced technology developments for industrial and defense applications.

The Magnetic Fusion Energy budget is organized into five interrelated functional areas that form the basis of a unified and balanced effort to conduct the research and development necessary to define a practical fusion product. The Confinement Systems and the Applied Plasma Physics subprograms, working in conjunction, provide the physics base for the Magnetic Fusion Energy program. In the near-term, the achievement of plasmas with the characteristics required to produce fusion energy flow from the experiments conducted in the Confinement Systems subprogram, with its dual focus on toroidal confinement systems and mirror confinement systems. The Applied Plasma Physics (APP) subprogram develops plasma physics theories and models to predict and explain the experimental results and suggest directions for additional investigations. Based on this information, the APP subprogram also initiates experimental and theoretical investigations of basic physics problems related to confinement concepts and develops diagnostic instruments for use by the Confinement Systems subprogram.

Using information developed by these two subprograms, the Development and Technology subprogram develops components and systems for use in near- and mid-term fusion experiments, and long-term generic materials. This subprogram also performs conceptual design studies for fusion power reactor concepts and next generation devices. These design studies identify component and system development needs that must be undertaken to prepare for the eventual application of fusion.

In carrying out the assignments of the physics and technology tasks, needs for major new facilities are identified from time to time. The Planning and Projects subprogram provides for construction of major new facilities and fabrication of auxiliary components for these facilities. Finally, the Program Direction subprogram includes the funding to cover salaries, benefits, travel, and associated expenses of the Headquarters Office of Fusion Energy. The proposed budget levels for these areas are indicated in Table 2.

This budget request reflects the continuation of the program's reorientation that was initiated in FY 1985. TFTR will proceed at a more deliberate pace, and operation of Mirror Fusion Test Facility-B (MFTF-B) at LLNL will be delayed until an adequate scientific base is available to make effective use of the facility. Initial tritium experiments on TFTR have been delayed until FY 1989 so that high-temperature, fusion-quality plasmas can be studied more thoroughly. By the end of 1986, we expect to achieve the equivalent of energy breakeven conditions in a deuterium plasma in TFTR. This should provide the information that would let us predict the requirements for achieving ignition with a deuterium-tritium plasma. The startup of

Table 2
Magnetic Fusion Energy
Budget Authority
($ in millions)

	FY 1985 Estimate	FY 1986 Request
Operating Expenses		
Confinement Systems		
Toroidal Confinement Systems	$151.1	$147.4
Mirror Confinement Systems	35.9	37.5
Applied Plasma Physics	82.5	78.1
Development and Technology	67.9	62.5
Planning and Projects	32.8	16.9
Program Direction	4.1	4.0
Subtotal	$374.3	$346.4
Capital Equipment	30.2	30.4
Construction		
Fusion Materials Irradiation Test Facility	3.0	--
Mirror Fusion Test Facility-B	20.1	4.1
General Plant Projects	9.4	9.1
Subtotal	32.5	13.2
Total	$437.0	$390.0

the MFTF-B facility will be postponed to allow a more thorough exploration of tandem mirror scientific principles in smaller mirror devices. The FY 1986 funding will support the postponement over the next two fiscal years of contracts for auxiliary components.

Several experimental tokamak devices will continue operation in FY 1986. Doublet III at GA Technologies in San Diego will begin operation under a U.S.-Japanese cooperative program. It will explore the limits of high beta operation through the use of elongated D-shaped plasmas. Alcator C at MIT will operate to provide physics data on the heating of high density plasmas, a basic factor in establishing the feasibility of an affordable ignition and burn experiment.

Investigation of toroidal improvements will be pursued with the completion of fabrication activities on the Advanced Toroidal Facility at ORNL and full operation of the Poloidal Beta Experiment at Princeton.

In the mirror program, researchers at the Lawrence Livermore National Laboratory will conduct experiments at the Tandem Mirror Experiment (TMX) facility to address the key physics issues of standard thermal barrier tandem mirrors. In addition, the TARA device at MIT and TMX will be used to investigate innovative mirror configurations that have the potential to improve linear concepts.

In the technology area certain long-term technology development activities will be deferred or reduced to allow concentration on near-term technologies needed to advance scientific understanding. The International Fusion Superconducting Magnet Test Facility at ORNL will fulfill our commitment to test six large superconducting magnets in a toroidal array. This will establish the technology needed to provide efficient, steady-state magnetic fields to confine plasmas for the tokamak concept. Development efforts will continue on pellet fuel injectors to support present fusion devices, and on ion cyclotron resonant frequency (ICRF) and electron cyclotron resonant frequency (ECRF) heating components to provide plasma heating systems for present and future fusion devices. Materials development needed to meet the unique requirements of fusion systems will continue with emphasis on developing coatings for high heat flux, materials for plasma interaction applications, and materials that will withstand radiation damage effects while concurrently producing little residual radioactive material. Exploration of copper magnet machine designs for ignition experiments and research on fundamental new materials will continue. However, to support these priorities, efforts on superconducting high field magnets will be stretched out, the neutral beam test facility at Lawrence Berkeley Laboratory will be shut down, and efforts in the area of tritium technology processing will be reduced. These efforts will be resumed when necessary to complete the fusion science and technology base.

Increased emphasis will be placed on studying some of the more fundamental aspects of fusion science. Research will be undertaken to exploit creative new ideas in both the reversed field pinch and compact toroid confinement concepts. These experiments should provide insights to enhance our understanding of how to better create and control a fusion plasma. Support of theory and small scale experimental plasma research will be decreased resulting in a reduction in the level of university support in these areas. The leasing of a new CRAY 2 computer for the Magnetic Fusion Energy Computer Center of Lawrence Livermore National Laboratory will continue to increase the computational capacity and capability of the Center which is used by fusion researchers throughout the program.

The request for Capital Equipment is $30.4 million and will provide the necessary hardware to support the planned experimental program. The Construction request of $13.2 million provides support for the program's General Plant Projects needs ($9.1 million) and completion of the construction activities on the MFTF-B project ($4.1 million).

Mr. Chairman, that concludes my testimony. I would be happy to answer your questions.

Senator **Evans**. Have we proceeded far enough—I am uncertain whether I should even ask the question, but have we proceeded far enough along in the research on fusion energy so that you can make any sort of prediction at all as to the potential in terms of a competitive alternative fuel source at some time in the future?

Dr. **Trivelpiece**. Well, I strongly believe that it will be a competitive fuel source or energy source in the future. The exact form which that takes and when that will occur is going to depend on a collection of things that, at the moment, would involve speculation to try to come to conclusions as to what they are.

First, it is necessary to demonstrate that you can create and confine a hot plasma and cause more energy to be released than was invested in putting the whole assembly together, and beyond that, then there is the necessity of the technology aspects of how you go from that to something that will deliver practical quantities of energy in a suitable manner. Beyond that, of course, are the economic issues and the insertion of competitiveness.

It would be really speculative to say that it will compete with something else, but at this stage, it seems to me that fusion will work and at some stage it will take an appropriate place in the energy supply system of this country and other countries.

Senator **Evans**. Is it possible to sort of put it on a time-and-practicality scale with some of the other energy research that is being carried out? For instance, I am always in wonder at the amount of money we have been willing to put into some of our synfuels program and then, as you mentioned, a cut of $40 million which would hardly be recognized in a $6 or $7 billion budget on that side—You know, where in terms of time and potential would you rank fusion energy as opposed to some of the work being done on synfuels, the work on photovoltaics—the whole range of other efforts that are going on?

Dr. TRIVELPIECE. Activities like synfuels, of course, involve more of a development activity in that you already know that you can heat coal in the appropriate manner and extract from it various kinds of fuels. There it is a question of being closer to pure economics rather than a question of scientific development.

The price of fuel is one of the determining factors, but it makes synfuels either practical or impractical and at the moment it is more market-driven than it is science-or-technology driven.

Photovoltaic cells work and there the problem is economics. They produce electricity at some number—I believe the current Sacramento Municipal Utilities District Project is buying cells, or would like to buy cells at $4 a watt, and the current price which I believe the vendor is capable of supplying is about $6 a watt.

That represents sort of the state of the art. There are a number of applications for which photovoltaics make great sense, and should be used. If the material science research would result in cells capable of $1 a watt or less, and high efficiency, that certainly would be an appropriate thing to do.

How to compare those with fusion isn't exactly obvious because, at the moment, fusion is at a stage where we are still trying to demonstrate the scientific feasibility of it, although I have no doubt that that will occur. To go from that step and make a forecast, would be a useful comparison, but would be very difficult.

I would comment that I think the fusion program, as such, is not technology limited but it is funding limited. The rate of progress at the moment is funding limited in that there are people who know what to do and are desirous of proceeding to do it, but we are in an economic circumstance in which the urgency to proceed is not as high as it was alleged to be back in the early 1970's when the energy crisis was first upon us.

Senator EVANS. I was reading articles in today's Washington Post of the sharp reduction in the energy potential from our Continental Shelf may bring some renewed interest. I am always astonished at how rapidly we seem to lose interest in our energy future when today looks pretty good.

What about the technology transfer you mention in your paper? "To provide the knowledge and experience in order to identify range of options for private sector investment."

Is there sufficient contact and technology transfer going on now, or is too early for much of that to happen?

Dr. TRIVELPIECE. A lot of it is happening and that is probably one of these issues that is a little bit in the eye of the beholder. I am sure that the industrial organizations in the United States would eventually like to be the vendors of the activities that may flow from the fusion program, would like us to do more in the way of involving industry in a direct and aggressive technology transfer effort.

The strategy has been one of involving them through the routine process of contracts and other activities. There are industries that are involved in this in various ways. Ebasco-Grumman was the constructor of the Tokamak Fusion Test Reactor at Princeton, and through that there is some routine transfer of science and technology into the industrial sector. But it is not, in the sense which I think your question implies, an aggressive technology transfer program in which there is a systematic collection of activities dedicated to that purpose.

It is more as a routine part of doing business at the moment.

Senator **Evans**. You mentioned that you are fund-constrained now. Would you estimate for me what it would take to reach that balance between what can usefully be spent and what we know how to spend effectively and efficiently, and the budget as the administration has now set forth?

Dr. **Trivelpiece**. Obviously, Senator, I am somewhat reluctant to engage in speculation about what the additional budget would do. I am here to defend the administration's budget for $390 million for this program and that is what we believe would be appropriate to do.

I think it is safe for me to say——

Senator **Evans**. Let's put it in terms of, the esoteric arguments, quite unrelated to budget constraints, what could we scientifically use if you make progress in the form and the speed we would like to, or could?

Dr. **Trivelpiece**. Well, I was not necessarily pleased by the reductions that did take place at the hands of the Congress a year ago. Certainly the levels that had been requested then represented what we believed to be a balanced program that would make effective progress in developing this energy resource. So, looking back at that particular point in time, I would say at that stage, that request represented a sound, well-balanced organized program.

Senator **Evans**. And that was at about $470 million, or something like that?

Dr. **Trivelpiece**. Yes, it was in that range, which has been the 1984–85 budget levels.

Senator **Evans**. How satisfied are you with our international collaboration? Where would you rank our research with that going on in other nations?

Dr. **Trivelpiece**. There are two questions; the collaboration, I think, is excellent. The fusion program, since its early days when it was first declassified in 1958 at the Peaceful Uses of Atomic Energy Conference in Geneva, has been characterized by very close cooperation. The scientists of the United States, Japan, Europe, and the Soviet Union have exchanged information through the traditional conference proceedings, and procedures, as well as engaging in joint programs and activities.

The United States and Japan have cooperated very well and Japan, in fact, has contributed $70 million to the activity at GA Technologies, and cooperation there is first class.

In terms of how well we do relative to them, I would say that in the Tokamak area, the Europeans, who have the Joint European Torus, that is located in England, have made excellent progress with that device and it is producing plasmas that are of a character that they advertised that it would and the TFTR device in the United States is producing similar conditions.

The Japanese will commission their JT–60 device on the 29th of May, and start operation of it. I have no doubt that they will rapidly achieve the parameters with that experiment that would put them in a comparable position with the United States and Europe.

So, in a sense, we are more or less all at about the same stage of development in producing conditions that are similar, temperatures that are similar and so on.

As far as the other aspect of international collaboration, I think I mentioned before, before Senator Bumpers, it has to do with the Versailles process; that process has led to the technology growth and employment part of the Summit process. We have done some studies on what kind of collaboration cooperation would be appropriate. I would be glad to make that report available for the record, if you would like.[1]

Senator EVANS. I think it would be helpful.

Mr. Chairman.

Senator DOMENICI [presiding]. Well, first, I want to thank you for presiding and I want to apologize for not being here, and I have to leave in about 3 minutes. I don't think I have to tell you what I am doing. My good friend, Senator Evans, knows——

Senator EVANS. I already told them. You are on the Lord's work and I hope you are on the Lord's side.

Senator DOMENICI. The only thing is, the Lord is putting all our guys in the hospital. I wonder whose side He is on, anyhow.

I have one question of Dr. Trivelpiece and three or four that I will submit for the record, and I wonder if I could ask Dr. Schriever one question. Is he here?

Could I start with you, Dr. Shriever? We have a formal review under way which will give us some outside perspective on the ICF budget. I think it is none too late because obviously OMB is doing their own cutting without the benefit of this kind of help, and they have the cut program in half. I am sure that isn't going to stick through Congress. We are going to put some money back.

But, my question, and this is parochial, but it does concern me; how will your outside review group properly judge the operation of the Sandia Lab Machine, which will not be finished until 1986, if the report is going to be ready by early 1986?

STATEMENT OF DR. RICHARD L. SCHRIEVER, DIRECTOR, OFFICE OF INERTIAL FUSION, DEPARTMENT OF ENERGY

Dr. SCHRIEVER. You and I discussed before the need for this kind of review and now, finally, we are in the process of doing it. But we have also talked about an evaluation of the program, to look and see later how these results were all coming out on these machines.

This review is looking more at the status and the directions and the payoff, rather than making an effort to judge specifically the performance of that machine. They are well qualified to look at the work on the machine and the things that have been progressing there and advise us on the quality of work and the appropriateness of the work, but they indeed will not be in a position to comment on the final usefulness and performance of the machine. We will do that later in some way.

[The prepared statement of Dr. Schriever follows:]

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[1] The report "Annual Report to the Working Group on Technology, Growth and Employment," has been retained in subcommittee files.

Senate Energy and Natural Resources Committee
Subcommittee on Energy Research and Development

May 9, 1985

THE DOE INERTIAL FUSION PROGRAM

by

Dr. R. L. Schriever
Director
Office of Inertial Fusion

Mr. Chairman, I am very happy to appear today to discuss the inertial fusion activities within the Department of Energy's Defense Programs. With your permission I will submit a written statement for the record and summarize the main points now.

We appreciate the committee's continuing interest and support for inertial fusion research and development. In this open session it is necessary to report on program developments on an unclassified basis. I am prepared to give you a private classified update on the program later if you desire.

Program Status

We have been pursuing a five-year plan to complete a number of construction projects and bring into operation three large experimental facilities: the NOVA glass laser at Lawrence Livermore, the ANTARES carbon dioxide laser at Los Alamos, and the Particle Beam Fusion Accelerator at Sandia Laboratories, Albuquerque. ANTARES and NOVA are complete and operating; PBFA II will be on line next year. In addition we have completed target fabrication facilities at Los Alamos and Livermore that are now in use. The glass laser systems in the kilojoule range that are in operation at the University of Rochester, KMS Fusion, Inc., and the Naval Research Laboratory, have been converted to short wavelength operation using operating funds. The experimental capabilities of the program are thus at an all time high. I would like to survey briefly the present program activities and technical developments centering around the use of these facilities and finish up with two topics, the FY 1986 budget request and the National Academy of Sciences review of the program that is now in progress.

NOVA

Building on the SHIVA glass laser operated from 1977 to 1980, Livermore has just brought into operation the 80-100 kilojoule NOVA glass laser system. NOVA has about a factor of ten more energy on target than SHIVA and operates at a half to a third of SHIVA's wavelength. Experiments during 1983-84 on the NOVETTE testbed, which consisted of the the first two beams of NOVA, demonstrated much improved target performance at shorter wavelengths. It should be emphasized that this demonstration is important for both the near-term weapons applications and for the potential longer term energy applications. NOVA works fully up to specifications as a laser, and the NOVETTE results lead us to expect that the targets shot on NOVA will perform as calculated.

The initial experiments on NOVA have just begun. These extend the successful x-ray laser experiments accomplished on NOVETTE last year, which I would like to discuss in a moment. About half the experimental time on NOVA is projected to be used for weapons-related work. Experiments of primarily inertial fusion interest, including more data on the scaling of target interaction phenomena at higher energy and high compression experiments, will be fitted into the schedule as funding permits. The other major activity at Livermore is the HALITE experimental program.

ANTARES

The ANTARES inertial fusion experiments at Los Alamos are essentially complete. The final series of experiments is now being written up. There is an important point about the ANTARES experiments that I would like to underline. The laser research and development and construction of ANTARES is a major engineering accomplishment in its own right. Large amounts of that understanding and technology will be applicable to pulsed high energy gas lasers of the future for inertial fusion and other applications. ANTARES permitted thorough study and evaluation of the long wavelength laser interaction. By the end of this year all the important physics effects will have been characterized and theoretically modeled. With this understanding, combined with the results of other work in the program, it is possible to calculate and predict the performance of pellets driven by long wavelength lasers.

We now know that the long wavelength laser approach to fusion would lead to high gain only with impracticably large, expensive systems. We can now understand and explain this physics in detail, and believe that this is an important achievement. Results from these experiments have also been essential in developing the quantitative understanding of the advantages of short wavelength lasers. The knowledge gained from research with the CO_2 lasers is an essential part of the base of understanding required for determining the potential of inertial fusion. Beyond these inertial fusion experiments, there are emerging a number of very useful applications of ANTARES to weapons science, including directed energy research.

In addition to these ANTARES experiments, Los Alamos has been pursuing both the classified CENTURION experimental activity and the development and characterization of a large aperture module of a krypton fluoride laser. KrF is potentially of great interest for fusion since it is a gas laser, like CO_2, but operates at the wavelength of a frequency quadrupled neodymium glass laser. The high energy pulsed KrF laser is also of potential interest in directed energy weapon research. We have deferred a program decision on further KrF laser efforts in inertial fusion pending the completion of the outside review of the program that is now under way.

PBFA II

Sandia's Particle Beam Fusion Accelerator II at Sandia is on schedule for completion of construction in January 1986. This is the last of the three driver facilities that were planned for the program in the 1970s.

PBFA II as a megajoule class machine theoretically has the capability in terms of raw energy to ignite a target. However, our program objective for this facility now is to test scaling of target interaction phenomena as conditions in the target approach ignition. It will be some time before we begin to understand the machine's full capabilities.

Encouraging results in beam focusing experiments have been obtained in experiments conducted on PROTO II and PBFA I. Scaling of these results to the much more advanced technology of PBFA II would indicate that PBFA II will meet the beam focusing criteria required for ignition scaling experiments. Thus, pulsed power is making progress toward the goal of demonstrating a fusion driver technology that is in many ways complementary to lasers. PBFA I experiments for the remainder of this calendar year will address various accelerator issues that need to be resolved in order to bring PBFA II into operation during 1986. Target experiments will therefore be delayed into FY 1987.

Support Laboratories

The University of Rochester Laboratory for Laser Energetics, KMS Fusion, Inc., and the Naval Research Laboratory constitute our major support laboratories. Their work is coordinated by Lawrence Livermore as the lead laboratory for glass laser experiments. However, each has broader contributions to its credit; for example, the target fabrication capabilities of KMS Fusion that have served the whole program, the strong theoretical group at NRL, and the functions of the LLE both in training graduate students and in staffing the National Laser Users Facility. The support laboratories lack the broader resources of the weapons laboratories to draw on when faced with inertial fusion program budget cuts. We have made an effort to sustain their activities at a productive level because we believe they should continue to have a role in the program alongside the weapons laboratories.

KMS Fusion's experimental program consists mainly of classified experiments that contribute directly to the data base for NOVA experiments. In addition, KMS Fusion will deliver at the end of this calendar year a cryogenic target handling system to Rochester for use on the frequency-tripled OMEGA laser. The cryogenic experiments, using the direct drive concept in which pellets are irradiated directly by laser beams, should give us a strong indication of the potential of this approach to laser-driven fusion. The Naval Research Laboratory here in Washington has just completed the upgrade of its PHAROS laser. NRL is supporting the direct drive effort by developing a technique for beam uniformity control called induced spatial incoherence. In addition, NRL has made significant contributions to the theoretical understanding in laser-target interactions that is applicable to both the direct and indirect drive approaches.

Weapons Applications

The dominant justification for pursuing inertial fusion research and development at this time is the capability this research affords to address some important issues in nuclear weapons physics. Further, pulsed laser and particle beam driver technologies can help address a number of the uncertainties involved in directed energy concepts. Of immediate application, though they cannot be discussed here in detail, are inertial fusion contributions to the complex computer code modeling, materials technology, micro-fabrication techniques, diagnostics, and measurements of materials properties at extreme pressures and temperatures. The program has been very successful in responding to opportunities to support weapons research and development.

Particular mention should be made of the x-ray laser experiments we referred to as in progress at this time last year. A set of radiation line measurements in materials identified as of special interest in the initial experiments was accomplished at KMS Fusion with participation from other laboratories. The experiments subsequently accomplished on the NOVETTE glass laser at Livermore confirmed what are believed to have been the first successful x-ray laser results in a laboratory. The flexibility of NOVETTE, and the capabilities in being at several program laboratories made these results possible. It is worth emphasizing this synergism between inertial fusion and related disciplines that made still another U. S. scientific first possible.

On this point it is difficult to be fair to the other weapons laboratories, Los Alamos and Sandia, as some of the outstanding experimentation involving the inertial fusion groups there is classified and cannot be described in an open session. As stated above, ANTARES has supported weapons physics and new concept experiments in addition to inertial fusion scaling experiments. PBFA I has also played a role in similar experiments, and as you no doubt know will be converted to a weapons program dedicated facility, for gamma ray simulation experiments, once PBFA II has been completed. We are aware of the Congress's concern for the effective use of these larger facilities which represent a substantial investment in machines and laboratory space for the national laboratories. The integration of inertial fusion and weapons-related research ensures a continuing return on the substantial investments in capital equipment and trained personnel.

Inertial Fusion Review

Under Congressional authorization the President has instituted a formal review of the inertial fusion program by the Director of the Office of Science and Technology Policy and the Director of Energy Research in the Department of Energy. A review group under the auspices of the National Academy of Sciences and chaired by Dr. William Happer of Princeton University is now visiting the participating laboratories and will submit an interim report shortly. You have raised the need for a review of the program in recent years, and it is a pleasure to be able to assure you the review is under way. Because of some delays in forming a balanced group the review is not coupled to the budget process for FY 1986. We are hopeful that the interim report due this summer will be helpful in formulating the FY 1987 budget request. The final report of the review is scheduled to be available early in 1986.

FY 1986 Budget Request

The President's budget request for inertial fusion is included in weapons research, development and testing activities in the Department's proposed budget, at approximately $70 million in operating funds. We believe this is the appropriate level at which to begin prioritizing within the weapons laboratories the research and development activities relating to both nuclear and advanced weapon concepts. The requested funding level has been determined only by priorities. We are not dropping any activities based on poor performance.

Within an overall budget constrained to very little growth after projected inflation, $70 million is the amount projected by Headquarters for inertial fusion activities. The weapons laboratory directors will provide additional funds for weapons-related experiments that use the inertial fusion facilities, in accordance with their priority needs.

Mr. Chairman, that completes my statement and I would be happy to answer any questions you may have.

Senator DOMENICI. Dr. Trivelpiece, you have proposed upgrades for the experimental machines. In both cases, because of the restraints you have imposed on you, budgetwise, you intend to pay for these out of existing funds for operations, if I understand the approach correctly.

Does this mean that you expect people to be laid off while these projects are under construction, and how could you run the machines once you have upgraded them if this is the case?

Dr. TRIVELPIECE. I understand your question. I am not sure I can answer it in the detail that you would like. I would like to supply an answer for the record on that.

Obviously, the budget cuts of the order that we have sustained will necessarily result in some terminations of employment. However, the numbers and the exact distribution of them and whether or not it reflects construction or not, I don't know off the top of my head.

Senator DOMENICI. Would you do that for us? It may just be an impossible one. You may be in that bind where that won't work, in which event we will just have to see.

[The information follows:]

From fiscal year 1984 to fiscal year 1986, the number of people working in the Magnetic Fusion Program will be reduced by over 700. Many of these are engineers and support staff as our larger projects are concluded, but we are losing some scientific staff as well. Nevertheless, we certainly intend to assure an adequate staff to operate the experiments we have proposed.

Dr. **Trivelpiece**. We have tried to preserve the scientific core individuals who are key to the program and not cause any layoffs in that arena.

Senator **Domenici**. We have three or four questions we will submit to you, Dr. Trivelpiece, for the record.

We have three additional witnesses. They are here. I have been trying, and we will continue for a few minutes more to see if we can get a Senator, or maybe two, if we could, to come and interrogate. If we can't, then we are just not going to be able to continue the hearing.

We will ask the three witnesses to submit their testimony and it will be made part of the record. If we have any questions, we will have to get ahold of the witnesses and inquire of them and have them answer the questions from the written interrogations that we will submit.

[The prepared statements of Dr. Robert L. McCrory, Dr. Allan T. Mense, and Mr. Mike McCormack follow:]

UNITED STATES SENATE

Ninety-Ninth Congress
First Session

COMMITTEE ON ENERGY and NATURAL RESOURCES

Subcommittee on Energy Research and Development

Statement for the Record

Robert L. McCrory
Director
Laboratory for Laser Energetics
UNIVERSITY OF ROCHESTER
Rochester, New York

May 9, 1985

SUMMARY

The University of Rochester's Laboratory for Laser Energetics (LLE) has completed its original five year agreement with the U.S. Department of Energy (DOE). Rochester was responsible for one of the most important breakthroughs in laser fusion, the development of high-efficiency wavelength tripling. The DOE has executed a new planned $23,468,000 three-year Cooperative Agreement with the University for the LLE (1) to continue research for the Defense Inertial Confinement Fusion program, using the frequency-converted OMEGA laser system, (2) to continue operation of the National Laser Users Facility (NLUF), and (3) to continue to educate students in the fields of fusion, engineering, optics, and physics. In order to continue a level-of-effort program (consistent with FY85), a total authorization and appropriation (which includes $750,000 for outside users of the NLUF) of $8,514,000 is required.

INTRODUCTION

The Laboratory for Laser Energetics of the University of Rochester occupies a unique position in the U.S. Defense Inertial Fusion Program. Established in 1970 as a center for investigation of intense radiation with matter, the Laboratory has the four-fold mission (a) to conduct basic physics experiments and research in support of the national short-wavelength laser program as well as demonstrating the feasibility of direct-drive laser fusion, (b) to provide graduate and undergraduate training in electro-optics, high-power lasers, high-energy-density physics, plasma physics, and nuclear fusion technology, (c) to operate the National Laser Users Facility, and (d) to conduct research in advanced technology areas related to high-energy-density phenomena.

LLE continues as an inertial fusion facility with significant non-federal funding, too. From its inception through 30 September 1984, more than $52.7 million of industry, university, and state funds have leveraged the $64 million federal investment. In addition to its key role in the U.S. Defense Inertial Fusion Program in laser-matter interaction experiments that support of the national short-wavelength laser effort, LLE is part of the University of Rochester and educates students.

EDUCATION

From its beginning in 1970, LLE has made the education of students one of its most important missions. This LLE mission is unique among the Inertial Fusion Program participants. The students come from departments and colleges within the university. While the largest number of graduate students come from the Institute of Optics and the Department of Mechanical Engineering, students from the Departments of Physics, Chemistry, and Electrical Engineering have been and will continue to be educated at the laboratory.

More than 200 students have received graduate and undergraduate training at LLE. Through June 1984, 41 students received Ph.D. degrees while working at LLE; 22 graduate students are currently engaged in Ph.D. research at the laboratory. Current graduate student research ranges from studies in hydrodynamics and parametric instabilities in plasmas to fundamental studies in nonlinear optics.

Graduates of the UR/LLE program are making significant contributions in a number of national laboratories, in industry, and in the nation's major research universities.

The laboratory is actively recruiting new students for graduate and postgraduate study and research in areas important to the Defense Inertial Fusion Program and to advanced technology development in general. As a result of a nationwide recruiting effort, more than 1000 responses have been received from potential applicants to the graduate research programs at LLE. Under the recently consummated DOE/LLE three-year Cooperative Research Agreement, LLE plans to increase the number of graduate students supported. Because of the long-term commitments the University makes to students, it is important that abrupt changes in funding be avoided.

THE UNIVERSITY OF ROCHESTER PROGRAM IN LASER FUSION

The University of Rochester has been involved in fusion research since the mid-1960's. It has pursued an expanded research program in conjunction with industry since 1972 at the Laboratory for Laser Energetics. The U.S. Inertial Fusion Program supports laboratory experiments which will determine the critical physics and engineering issues necessary to determine the scientific feasibility of igniting small fusion fuel masses.

Presently, the National Academy of Sciences (NAS) is reviewing the National ICF program, as requested by the Congress. I urge that the Congress not allow the Administration to judge the program to need less money. I believe the program should continue while the Congress and the Department of Energy work with the NAS Technical Review group to arrive at a decision for the future of ICF. Present experimental strategy calls for the use of laboratory drivers to acquire data which will help to unambiguously determine the marginal ignition boundaries for small fuel mass systems. These data are vital to the nation's nuclear weapons physics research, and are also necessary in developing the potential for inertial fusion to become an attractive energy source for the future.

In the early 1970's, the University funded the fusion research effort almost exclusively through its industrial sponsors. As the program evolved from a bench-scale effort to a laboratory scale, the University elected to meet a national goal of laser fusion feasibility research using the joint support of the Federal Government, industry, utilities, the State of New York, and the University of Rochester. Approximately $117 million have been invested in the program since 1972. Approximately 46% of the total has come from non-federal sources. In effect, at Rochester a new and different kind of "national laboratory" has been created.

The fiscal year ending September 1984 (FY84) marked a milestone in the history of the Laboratory for Laser Energetics. It was the fifth year of the initial five-year research contract with the U.S. Department of Energy.

In the five years represented by the DOE/LLE supporting research program, 15,341 shots were recorded by the 24-beam, 12-terawatt OMEGA and one-beam, 1-terawatt GDL laser systems. More than 6000 of these were on-target shots. This represents one of the most extensive data bases on 1054-nm and 351-nm laser interaction with matter.

The University of Rochester was first to demonstrate and patent the high-efficiency, frequency-tripling process. Dr. Schriever, Director of the U.S. Department of Energy Office of Inertial Fusion has stated:[1]

> "In the laser fusion area, the most important breakthrough has been the development of efficient wavelength conversion, now being implemented on NOVA and OMEGA."

The full OMEGA system is now fully frequency-converted to 351 nm. The OMEGA system, with its high repetition rate capability and reliability will enable accumulation of crucial data necessary to understand the physics scaling laws of inertial fusion using short-wavelength lasers in a symmetric ("direct-drive") illumination geometry. Understanding the physics scaling laws means we must verify predicted target performance as target size, laser energy, and wavelength are varied. Rochester's critical role in the National Program will minimize the technical risk associated with the Inertial Fusion Program as well as provide an alternative approach to laser fusion.

During the past year several major experimental campaigns were carried out on OMEGA. These campaigns investigated (a) illumination uniformity, (b) coronal physics, (c) energy transport and ablation, (d) high-Z plasma dynamics, (e) atomic physics and x-ray laser physics, and (f) fusion diagnostic development. A number of these experiments were carried out in collaboration with other inertial fusion laboratories.

The results of these experiments, reported in LLE's FY 1984 Annual Report,[2] give renewed promise for the successful demonstration of direct-drive laser fusion. Direct drive is an important research tool needed to advance inertial fusion research, and provides a wealth of high-energy-density physics data. Atomic physics, laboratory astrophysics, x-ray laser physics, and x-ray generation are a few of the areas that have benefited from research devoted to understanding the basic physics of laser-matter interaction.

Work at LLE and elsewhere has shown that the illumination uniformity required for high-convergence implosions can be achieved with laser technology already developed. Short-wavelength, laser-matter-interaction experiments have confirmed the expectations of high absorption, low preheat, and high ablation pressure.

The short-term (1- to 3-year) objective of the LLE program is to demonstrate sufficient drive uniformity with the 24-beam OMEGA system at 351 nm to compress targets to densities in excess of 20 g/cm^3. The OMEGA system converted to full 24-beam, 351-nm operation has begun operations at the 2000-J level. Up to 2400 J of 351 nm light has been put on target. On April 15, 1985, the newly converted OMEGA was used in a target experiment which produced a new world record yield of 165,000,000,000 neutrons. This experiment surpassed the previous Japanese record by more than a factor of three; the Japanese used nearly ten times the laser power required by the Rochester experiment. The high yield experiments will be used to perfect new instrumentation, such as neutron imaging, in support of the National Program. It is expected that densities of the order of 10 g/cm^3 can be achieved on OMEGA by 1986 using gas-filled targets. Improvements in illumination uniformity and cryogenic targets are expected to produce higher densities, of the order of 20 g/cm^3 by mid-1987.

OPERATION OF THE NATIONAL LASER USERS FACILITY

A second unique characteristic of the Rochester program is the National Laser Users Facility (NLUF). Since 1979, 42 proposals have been approved for the facility. In addition to investigations in the general area of inertial fusion, approved experiments have also included investigations in plasma physics, x-ray laser development, XUV spectroscopy, and instrumentation development. Researchers from Brigham Young University, Los Alamos National Laboratory, the National Bureau of Standards, the Naval Research Laboratory, the Goddard Space Flight Center, Physics International, Inc., Polytechnic Institute of New York, University of California (Davis), University of California (Los Angeles), University of Connecticut, University of Illinois, University of Maryland, University of Pennsylvania, University of Texas, and Yale University have participated in NLUF experiments.

PROGRAM FUNDING AND MANAGEMENT

On October 1, 1985, the Department of Energy executed a new three-year Cooperative Agreement with the University of Rochester. The new agreement funds the Laboratory for Laser Energetics at a planned $23,468,000 over three years ($7,428,000 for FY85, $7,764,400 for FY86, and $8,275,600 for FY87). These agreement amounts do not include funds which are provided directly to the NLUF users. The dollar amounts were the result of a series of negotiations with the Department of Energy, the last of which occurred in July, 1984.

The negotiated Agreement with the Department of Energy establishes Rochester's program as a level-of-effort program (consistent with FY85) for FY86 and FY87. The agreement funds 63.6 man-years per year for each of the three years. The equipment funded in FY85 includes $704,000 for the blue conversion. For FY86, equipment purchases are anticipated for replacement parts necessary to operate the system ($695,000), and diagnostic equipment required for the experimental campaigns ($437,000).

In order to operate the newly converted system and conduct the experiments which will produce high densities and temperatures in laser-driven inertial fusion capsules, as well as to continue its mission to educate students and operate the NLUF, LLE requires total funding of $8,514,000 for FY86.

We expect that the laboratory will continue to play an important role in the Inertial Fusion Research Program, in the training of the nation's scientific leaders, and in the development of advanced technology.

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1) S. HRG. 98-1175, Hearings before the Subcommittee on Energy Research and Development of the Committee on Energy and Natural Resources, United States Senate (March 5, 12, 20, 22, April 5 and 24, 1984), p. 836.

2) University of Rochester, Laboratory for Laser Energetics Annual Report, DOE/DP/40124-67 (January, 1985).

1884 · 1984
A CENTURY OF ELECTRICAL PROGRESS

IEEE TECHNICAL ACTIVITIES BOARD/UNITED STATES ACTIVITIES BOARD
ENERGY COMMITTEE

STATEMENT

of

DR. ALLAN T. MENSE

of the

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

on

FUSION ENERGY RESEARCH

Before the

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

May 9, 1985

I am Allan T. Mense, Senior Scientist with the Fusion Science Department of the McDonnell Douglas Astronautics Company and the Vice Chairman of the Institute's Energy Committee. I am appearing before you this afternoon to present testimony on behalf of the Energy Committee of the Institute of Electrical and Electronics Engineers (IEEE). The IEEE is the world's largest engineering society, with nearly 260,000 members worldwide, 215,000 of whom live and work in the United States. Approximately 82% of our membership is employed in industry, 8% in academic institutions, and 10% in the various government laboratories and agencies. The Energy Committee itself has representatives from 32 different technical societies (within the Institute) and 6 different geographical regions. The Committee is vested with the authority to develop the Institute's energy policy and, once that policy is adopted by the Institute, we are one of the major mechanisms by which the policy is voiced in public.

We are pleased to have been given the opportunity to appear before you today and address the very important area of fusion energy development. We continue to believe that fusion possesses the highest potential of all presently known energy sources and wish to commend this Subcommittee for its strong support of the fusion effort in the past, particularly in the face of the dramatic reductions imposed by the Appropriations Committees in the last Congress. Rather than cover the entire gamut of fusion related activities, we have chosen to address a few major issues which we believe require serious Congressional attention.

The issues are:

1. The need for an ignition/burning core experiment.
2. The declining role of fusion under the Reagan Administration.
3. The advisability of international cooperation.

Now let me address the most troublesome problem first.

1. The need for an Ignition and Burning Core Experiment

The IEEE United States Activities Board, in its most recent position paper on Fusion Power dated November 29, 1984, "recommends that the Department of Energy immediately embark upon the design and construction of the next major evolutionary step in the fusion program, generally referenced to as the 'Burning Plasma Experiment'."

Let me elaborate on the reason for this position. The fusion program requires one final piece of critical scientific information before it can, with some certainty, develop a practical power producing fusion reactor: the operational characteristics of an ignited and burning plasma core. The present Department of Energy funding levels for fusion preclude the possibility of obtaining this data for the next 10 to 20 years.

If the program is not allowed to move forward with a certain minimum momentum, then one of the consequences is a gradual but noticeable reduction in trained personnel. When major facilities are not aggressively operated (e.g. TFTR) or constructed (MFTF-B), then people in the program become frustrated with the best people attracted away from fusion. (We are seeing this happen now.) When the best people leave and the operating time of an experiment is reduced, there is less scientific progress. When the Congress and OMB see less progress, then more-often-than-not the result is reduced program funding. This puts the program into an unwise, ever-declining funding spiral. The IEEE Energy Committee believes that if the program is to maintain any semblance of initiative, it must be allowed to move forward to construct facilities for studying an ignited and burning plasma.

Our position on this is thus very much at odds with the Department of Energy's present Magnetic Fusion Program Plan which does not envision a line item for an ignition experiment until 1990 at the earliest. The country will have spent $1.6 billion in additional fusion support before the Department even plans to ask for this experiment. We consider this plan unacceptably long.

2. Why has fusion received reduced funding compared to other major scientific programs within the Administration?

Let us make the case with statistics. Within the Department of Energy's Office of Energy Research (OER), in which the fusion program resides, fusion funding requests, of all the OER programs, have not faired well. Through the present fiscal year (1985), High Energy Physics increased by nearly 50% from $364.5 million in 1982 to $545.6 million in 1985. Nuclear Physics increased by 37% over the same period and Basic Energy Sciences increased from $241 million to $422.6 million or over 75%. In the 1982 to 1985 period, fusion experienced a 7% growth in terms of requested funding. However, due to a $46 million reduction in the 1985 Appropriations Bill, fusion has experienced a 3% overall decrease in funding, the only OER program to have less dollars in 1985 than in 1982.

It appears that 1986 will see the budgets for most non-military programs cut, and it appears that fusion will not be an exception (The $390 million FY'86 requests imply a net program reduction of over 14% since 1982.) See Table 1.

TABLE 1.

BUDGET HISTORY OF SELECTED SCIENCE PROGRAMS

FISCAL YEAR	(MILLIONS OF DOLLARS) HIGH ENERGY PHYSICS	NUCLEAR PHYSICS	BASIC ENERGY SCIENCES	FUSION
FY 82	364.5	133.9	241.2	451.2
FY 83	431.0	137.0	282.4	461.3
FY 84	472.9	163.2	335.6	468.4
FY 85 (est.)	545.6	182.9	422.6	437.0
FY 86 (proposed)	510.1	172.9	406.8	390.0
% change FY'82 to FY'85	50%	37%	75%	-3%
% change FY'85 to FY'86	-7%	-5%	-4%	-11%

Independent of the magnitude of the fusion budget, one must still try to understand the logic behind the present funding for fusion. To get a handle on this problem, let me review the objectives of the fusion program.

The fusion program has the well-recognized long-term goal of providing the world with essentially limitless energy from sources (deuterium extracted from water) which enjoy no geographic or political boundaries.

The specific objectives and benefits of fusion research depend on the timeframe in question. In the medium-term, fusion reactor technology development and demonstration will stimulate the country's innovative engineering, materials development, and industrial project management capabilities.

In the near-term, fusion research will address the most challenging scientific problems mankind has ever tackled, and if properly administered, provide the country with many important spin-offs. This is the phase which begins to repay the taxpayers for their patience and investment. Thus, it would appear that fusion is not only a strong and worthwhile scientific endeavor, but it also has a clearly visible and practical end goal.

If the Administration, with the approval of Congress, wishes to fund "good-science-for-the-sake-of-good-science," then fusion, being one of those good sciences, should receive its fair share of support.

If, on the other hand, it makes good sense to give increased importance to those areas of good science which also have visible practical end uses, then again fusion also deserves increased funding. In either case it is clear that fusion has been overlooked. The House Science & Technology Committee recently took action to diminish this trend by approving an authorization for Fusion which was $25 million over the Administration's request. We urge this Committee to join with them in passing a comparable Authorization bill. I will have more to say about this near the end of my testimony.

Let us proceed to the final troublesome point..

3. The Limits and/or Advisability of International Cooperation in Fusion Research.

Again from our own position paper we state, "the IEEE urges the continuance of broad areas of international cooperation in promoting fusion power research."

Thus we endorse open international scientific collaboration. The U.S. has already had very profitable scientific exchanges and should continue to do so. It is the technology exchange which should be of concern. The reason for the concern stems from the fact that the United States government has not had in the past, and continues to lack a government-industry policy. Meanwhile, other countries, which subsidize their industry to penetrate U.S. markets, make the best of this predicament by using our technology developments as a blueprint for implementation and then beat us by manufacturing products at lower costs. It is hard enough to compete with the present lead times for technology transfer. We need not reduce those times even further. It would be useful for Congress to take some position on this issue and Fusion Energy R&D may be a good program in which to address this concern, particularly since the Department of Energy states quite clearly in their program plan that "the milestones (for fusion) should be interpreted as goals that can be achieved with steady domestic support and significant international cooperation and collaboration." (The underlining is mine). This type of statement says to us that the U.S. cannot do the program (even the most modest one presently proposed) without money and/or facilities from abroad. If so, then the country must be prepared for the consequences:

- reduced technology spin-offs to the U.S. taxpayer (who has already shouldered over $3 billion in costs to date);
- reduced incentives for U.S. industry to participate and bring their own financial contributions;
- reduced public commitment to the national goal of fusion power.

I have briefly covered the primary areas of the Institute's concerns. There are, however, several areas of lesser concern worthy of the Subcommittee's attention. I list them below and can elaborate more fully if necessary.

1. During major funding reductions the universities usually pay a disproportionate price. While this does not appear to be the case in FY '86 for fusion, the Congress should maintain an awareness of the importance of the university role in a successful overall fusion development plan.

2. Both Tokamak and Mirror confinement approaches enjoy the benefit of being technically coordinated by so-called "lead laboratories." It may be advisable for the compact reactor concepts to be technically managed through a lead laboratory. Los Alamos would certainly be a logical candidate for such a position.

3. It has come to the Institute's attention that fewer of the really outstanding students are choosing fusion/plasma physics as a discipline for graduate studies. This is usually a precursor to reduced scientific progress, reduced program momentum, and increased technical frustrations. These are bad symptoms and will ultimately affect program health and stability.

Summary and Final Thoughts

In closing, the Institute is asking Congress to do at least two things:

1. Fund DOE to initiate an ignition experiment sooner than currently planned; it is the way to obtain operational characteristics of an ignited and burning plasma core.

2. Do not allow international cooperation to be built on the basis of technology give-away, but upon equal partnerships in science and education.

Let me state quite clearly that the Institute understands and desires that Congress and the Administration exercise restraint in government spending. To help control the budget deficit, fusion funding must clearly give its fair share. What we have proven in our testimony here today is that fusion has given far more than its fair share. Please help.

As a final point, let me state that, while it isn't the Institute's policy to tell Congress how to do its business, we feel it important to emphasize a factor of increasing concern to the technical community. There has not been an Energy Authorization Bill signed into law since PL95-238 in FY'78.* We all understand the reluctance on the part of the Senate to undertake Committee debates on authorization bills, only to repeat the same arguments as members of the Appropriations Committee. The Institute, however, cannot help but think that if there had been a 1985 DOE Authorization Bill signed into law last year, the House Appropriations Committee might not have decimated the fusion budget so severely. If you will recall, fusion experienced the largest appropriations reduction of any Department of Energy program in FY'85. The IEEE believes that passing an authorization bill and having it signed into law exercises far more influence than one might at first believe. To establish science, and energy in particular, as a priority item can only be done through the Congressional authorization cycle.

We would encourage the Committee to pass a bill this year as we have already encouraged the House to do likewise.

Thank you for giving us your time and attention. If there are any questions, I will be happy to answer them.

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* The Ominbus Reconciliation Act of 1981 did include authorization for FY'82 and proposed ceilings for FY'83 and '84.

SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

TESTIMONY BY
THE HON. MIKE McCORMACK

A NEW DIRECTION -- AND NEW INITIATIVE -- FOR FUSION RESEARCH

- **costing much less**
- **possibly accomplishing much more, much sooner.**

Based on these assumptions:

1. Funding for a large "next step" fusion device ($1 billion to $4 billion?) is unlikely ... federal, private, international.
2. Large (expensive) fusion machines would be impractical for most commercial applications anyway.
3. **The fusion program must not be "pure research only".**

   It must have a purpose and a meaningful goal.
4. It appears likely that fusion burns can be achieved in several different designs of small fusion machines.
5. Small machines are remarkably cheaper to build and test -- and may be practical for power production much sooner.
6. Industry may be interested in getting into fusion research if there is a place to test small machines (with d-t burns).

We need such a place -- A Fusion Research Center -- at a DOE site -- with the following features:

- remoteness
- security
- NRC and DOE supervision
- tritium handling
- available hot labs
- radiation monitoring and control
- waste disposal
- adequate (low-cost) electric power
- on-site scientific and engineering support

McCormack proposal:

That the Energy Research and Development Subcommittee request DOE to conduct a study of such a site -- in time for consideration as part of FY 87 budget.

TESTIMONY

BY

HON. MIKE McCORMACK

SUBMITTED TO

COMMITTEE ON ENERGY AND NATURAL RESOURCES

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

9 May 85

Mike McCormack served in the House of Representatives from 1971 through 1980. He was Chairman of the Subcommittee on Energy Research and Production of the House Committee on Science and Technology. McCormack was the author and prime sponsor of Public Law 96-386 -- the Magnetic Fusion Energy Engineering Act of 1980.

McCormack is an independent consultant. He is not retained by anyone to submit this testimony. McCormack is expressing his own thoughts, and speaking for himself alone.

Thank you, Mr. Chairman. I'm pleased to have this opportunity to appear before you and discuss some recommendations for our magnetic fusion energy program.

Mr. Chairman, I respectfully suggest that the DOE be requested to conduct a study of the nature, approximate cost, feasibility, and other primary characteristics of a Fusion Research Center, to be located at a DOE site with the following features: remoteness, security, NRC and DOE supervision, tritium handling, available hot labs, radiation monitoring and control, waste disposal, adequate (low cost) electric power, and on-site scientific and engineering support.

This suggestion is based on several assumptions which I believe to be realistic, even though they may be only reluctantly accepted by some. They are:

1) There is little likelihood of federal funding -- and certainly less of private funding -- for a new large "next-step" magnetic fusion experiment within the foreseeable future in the U.S. Such a large "next step" machine, as envisioned in recent consideration of a TFCX, would be a tokamak somewhat larger than the TFTR and capable of limited deuterium-tritium burns.

Estimates of the costs of such a machine vary from $1-1/2 to $2 billion, but as far as I know, this does not include any serious consideration of -- or provision for -- realistic remotization of the facility, or the handling of the many pieces of equipment that would become radioactive from exposure to neutrons. (Such provisions would probably double the cost of the machine.) Thus, such a machine may not be considered as a realistic prospect for the foreseeable future in this country.

2) The likelihood of meaningful international cooperation to construct such a machine is, I believe, quite low. I do not argue that it should not be pursued, but I suggest that such a path will be fraught with endless difficulty, frustration and delay. I do not consider it realistic for the United States to place its dependence for the future of fusion research and development on international cooperative funding.

3) It is highly unlikely that a large machine would be a realistic step toward practical commercial application. Today we are witnessing a strong tide of opinion favoring smaller fission machines. Utility executives tell me that they would be even more reluctant to invest very large sums of money in large fusion machines than they are today in large fission plants.

4) From all this, I conclude -- as I think many other thoughtful observers have concluded -- that the U.S. should not continue large machine programs beyond the scheduled operation of the TFTR.

Yet we have a mission -- and we must contrive to accomplish it: to provide the research and development that will lead to early commercialization of fusion power. If we are to reach this goal, it now appears that we must do it through the development of small machines. It is now obvious that small fusion machines will be much less expensive per KWH than large ones. Perhaps they can be made inexpensive enough -- and practical enough -- to be attractive for commercial use.

5) A great deal more is understood now about plasmas in small machines than was assumed likely even two or three years ago. Many of the apparent obstacles have been substantially overcome; and from my private conversations with some of the leading plasma physicists in the country, I can report that there is today a significant new body of opinion supporting the idea that small machines could be built that will attain fusion-burn conditions, even though they may differ radically in design from each other and from large machines, and may put higher demands on materials.

Not only would such small machines have the advantage of being much less expensive, but it is also is quite conceivable that, when they become "worn-out", they can simply be removed from an operating cell, stored in a shielded cell and allowed to cool for several years -- and new machines installed to replace them. These might be "zero-maintenance" machines, used -- quite like light-bulbs -- and then replaced.

The estimates of the cost of such machines vary from $5-10 million each, a tiny fraction of the more complicated big machine. Small machine designs include very small tokamaks (such as the Riggatron), the OTHE of GA Technologies, and additional reverse field pinch or field reverse configuration machines, spheromaks, and certainly others.

6) There is considerable interest in designing such machines within private industry. Mr. John Landis, Executive Vice President of Stone & Webster Engineering recently commented on this interest -- and a greatly increased industrial involvement -- in remarks delivered at the annual meeting of the Fusion Power Associates in La Jolla on February 1, 1985. Mr. Landis suggested a vigorous initiative to involve private industry in magnetic fusion research and development, and suggested that the DOE make all relevant information on fusion research available -- without cost to industry. He believes that this will lead to industrial involvement and the creative innovation that industrial competition always brings.

I applaud Mr. Landis' suggestion, but one major obstacle stands in the way of industrial participation. That is the realization that even if a small machine developed by private industry is able to achieve Lawson criteria, the next step would require a research site that could handle a fusion burn.

Such a site would not be on a college campus or in a conventional industrial laboratory. It would, of necessity, be located at a DOE facility with all of the pre-existing facilities that major DOE facilities provide: remoteness, security, NRC and DOE supervision, tritium handling, available hot labs for examination, radiation monitoring and control, waste disposal, adequate (low-cost) electric power, and scientific and engineering support from experienced on-site contractors.

Accordingly, Mr. Chairman, I respectfully suggest that the DOE be requested to conduct a study of the nature, approximate cost, feasibility, and other primary characteristics of a Fusion Research Center, to be located at a DOE site with the facilities I have mentioned. I should observe that Inesco projected that such a site, with two test bays, hot storage facilities, remote handling equipment, a very large motor generator, electric conversion systems and electronic controls, tritium handling facilities, and the most modern diagnostic systems could be built for $150 to $200 million within less than five years. Included in the Inesco projection was the cost of building and testing five small machines. I provide this data only to suggest a "ballpark" estimate of the cost of a Fusion Research Center, and to put it into context with the total funding available from magnetic fusion research.

If one assumes an average funding level of $300 million a year for the next five years, one would conclude that if the basic assumptions I make have even a modest degree of validity; then the cost of a Fusion Research Center such as I suggest does not appear to be unreasonable.

A Fusion Research Center would be available to any governmental agency, such as the Department of Energy or Department of Defense, to test small machines without cost, and should be available to private industry to test machines, retaining proprietary information, for only the added cost involved.

Machines developed jointly by the DOD or DOE with private industry could also be tested. This is similar to the policy developed by the NASA for the use of its wind tunnels by public or private agencies. I see no legal or legislative obstacle to such an arrangement for a Fusion Research Center. It is, in fact, consistent with Administration philosophy of encouraging private industry to develop promising energy technologies; and it is consistent with the existing DOE philosophy of encouraging private contractors to use non-defense DOE facilities for research.

Mr. Chairman, this testimony may lack some of the sophistication or detail that would be expected if it were submitted as the product of some large, funded study. I trust that you will accept it as a simple attempt to make a constructive -- and I hope helpful -- suggestion, without attempting to go into great detail concerning it.

I believe that if the Committee requests that the DOE conduct a study such as I have suggested, it will be of great value to you -- in the near future -- as you provide guidance for the fusion program.

I thank you for inviting me to testify before the Subcommittee. I will, of course, be pleased to attempt to answer any question or to provide additional information.

Senator DOMENICI. What we are going to do now is stand in recess for 10 minutes. If it happens that we cannot get a Senator, then we will have recessed at this hearing at 5 minutes, with nobody present.

I am very sorry and I apologize, again, to the witnesses. I can do it no other way.

We will stand in recess in a conditional way, pending the arrival of Senators to interrogate. If not, we will accept the testimony.

Thank you, very much.

[Whereupon, at 10:10 a.m., the hearing was recessed, subject to the call of the Chair.]

APPENDIX III

RESPONSES TO ADDITIONAL QUESTIONS

POST-HEARING QUESTIONS AND ANSWERS

FROM SENATOR JEFF BINGAMAN

FOR DR. TRIVELPIECE AND DR. R. SCHRIEVER

Relating to

FY 1986 AUTHORIZATION HEARING

Before the

SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

MAY 9, 1985

Question 1: I would just like to hear your ideas on the future of fusion research in this country. A few years ago, fusion was seen as achievable in the first decade of the 21st century. Was that a realistic assumption? What is a reasonable date we can expect fusion to be commercially viable?

Answer: Earlier estimates regarding the completion of fusion development were based on the assumption of certain funding profiles. Due to the present budget situation and an easing of the short term energy supply situation, funding for completion of the program in the first decade of the next century has not been available. The current schedule for the completion of magnetic fusion is keyed to the resolution of the technical, political and economic uncertainties of the world energy supply. I believe that with continued support of the Magnetic Fusion Energy program, we will be able to develop an adequate scientific and technological base to make an assessment of the economic and environmental characteristics of fusion energy by around the turn of the century. The subsequent schedule for the development of a fusion power system will be determined by the outcome of this assessment and a comparison of fusion energy with other acceptable energy systems which might be available at that time.

Question 2: With respect to the issue of commercial viability, do you believe our present research efforts with the Tokamak at Princeton and the Mirror at Livermore will lead us to a design we can produce commercially? I realize the Tokamak may offer the best chances for us to reach breakeven. However, will we be able to produce a commercial prototype from this design? Shouldn't we concentrate more attention on alternative designs?

Answer: At the present time, there are several confinement systems that could develop into reactor candidates. However, in spite of continuing technical progress, it is not yet possible to design a commercial fusion reactor with any degree of certainty. It is quite possible that proposed improvements in the tokamak and tandem mirror concepts will lead to commercially viable fusion systems. However, it is also likely that economical fusion systems will require features from other types of magnetic confinement systems. The history of fusion development has shown that the cross-fertilization between related concepts leads to more rapid progress in all confinement systems. Although budget constraints preclude parallel development of all possible confinement systems, it is essential to explore an appropriate range of possibilities for magnetic confinement, including promising improvements in the tokamak and mirror confinement systems. I believe the proposed program reflects the correct balance of effort.

Question 3: Despite the 11 percent reduction in overall Magnetic Fusion Energy funding, the Advanced Fusion Concepts (AFC) part of the President's FY 1986 budget calls for two new devices in the compact high-power-density area. Los Alamos is a strong contender for both of these new devices. However, there is a serious problem. In order to fund the construction of these devices from the proposed AFC budget, support for staff vital to these projects will have to be traded for procurement to build the devices. It seems to me that a reduction in personnel only hinders our ability to carry out a long range technical program. I am concerned with this trend. I would think that continuing research during part of the design and construction period would assure the most up-to-date device and diagnostic capabilities. It also would provide the highly trained scientific staff needed to operate the devices when construction is completed without having to embark on a costly recruitment and training effort. Can you please comment on the general trend of forcing laboratories to cut back on scientific personnel in order to provide for new plant and equipment?

Answer: We are also concerned about preserving the unique scientific resource represented by our fusion experimental teams. However, even in a difficult budget climate, the fusion program cannot afford to allow research progress of these teams to stagnate. We feel our only option is to trade operation time for the required new facilities. The reversed-field pinch device that we wish to fabricate is a case in point. We intend to replace a device at Los Alamos that was designed in 1976, was placed into operation in 1979, and which had exceeded its original performance goals by 1984. In order for this research to progress, the new device needs to be started promptly.

Office of Fusion Energy personnel are working with the management at LANL to effect as smooth a transition as possible of the vital scientific staff from the present experimental program through the construction period to the period of operations on the new device. Many of the scientists will remain with the project through construction. Others will be used to meet temporary needs for plasma physicists both within LANL and at other fusion laboratories as well as in our international cooperative program. We believe that these measures should be adequate to engage all of the vital scientific staff.

Question 4: I am especially interested in our efforts at the international level to further fusion research. At the Versailles Economic Summit, recommendations were made for increased cooperation among our allies in fusion research. I understand the Japanese and the Europeans are currently working on the Tokamak design. What progress have we made in increasing our international cooperation? Has this effort proved successful? Do you think we should coordinate our research efforts so that we are not all pursuing the identical technology at the expense of other alternatives which will prove more commercially viable in the long run? Was there any progress on this at the Bonn Economic Summit?

Answer: Since the Versailles Economic Summit in 1982, the coordination of international fusion activities has increased significantly. Following this Summit, a policy level Fusion Working Group was convened to develop a framework for enhancement of international fusion collaboration among the Summit participants. I am pleased to note that this Working Group effort is proving successful. In particular, joint planning has been initiated to identify the nature and timing of major facilities required to complete the fusion effort. Recently, the U.S. plans for one such facility--a facility to investigate plasma ignition and burn--were reviewed in the light of the overall Summit Nations' fusion plans. The net result was an endorsement of the usefulness of our plans, which complement those developed by the Japanese and Europeans. The key issues of fusion nuclear technology, material development and development of magnetic confinement systems will be addressed next.

We have recently signed or prepared agreements for collaboration on major European research facilities. Our principal scientific workhorse program, the conventional tokamak program, is now based on three existing U.S. facilities and three major new European facilities. Through these collaborative arrangements, we have avoided the hundreds of millions of dollars of capital costs associated with these facilities. In each case, the U.S. brings valuable scientific expertise, specific components and skilled personnel to the collaboration in return for access to and participation in the research at the facility. All of these efforts are intended to avoid needless duplication.

Our efforts were reported at the Bonn Summit where our progress was noted with approval. In looking to the future of enhanced collaboration, it is important to understand the time scales involved in both fusion research and international consensus building. The time scales for both are measured in years. I think we have made a positive start toward the desired improvement in collaboration, but continued attention at all levels will be required to ensure long term success.

Question 1. The Armed Services Committee took action this year durng the mark up of the Defense Authorization Bill to increase funding for the Inertial Confinement Fusion program. The Committee felt that the Administration's proposed budget request would lead to a reduction in the level of dedicated scientific teams at the various laboratories at a time when the sytems are transitioning from construction to operation and would deny the systems the capability to produce the useful scientific data for which they were designed. Second, the Committee felt such cuts were premature until the National Academy of Sciences Technical Review Group, set up by the President at the direction of last year's defense authorization bill to assess the merits of the ICF program, made its findings. The Committee recommended a $155 million mark, an increase of $85 million over the Presdient's request. Do you feel this is a realistic figure to continue ICF research?

Answer. Yes. At the $155 million level, inertial fusion activities could continue at about the fiscal year 1985 level, less inflation. There should be some redirection of program efforts, as is natural since the program is evolving toward answering some of the longstanding driver issues. ANTARES experiments are expected to be completed during this fiscal year. We will see the first full year of NOVA experiments. The Particle Beam Fusion Accelerator II at Sandia, Albuquerque, will be completed and characterization of machine performance will start during fiscal year 1986. The remaining program activities we would expect to continue at essentially the same level.

Question 2. I believe the Technical Review Group is to release an interim report by June 1. Will the report be ready at that time? Do you have any indication of what the initial findings might be?

Answer. The Technical Review Group has scheduled meetings that would allow it to complete its interim report early next month. I have heard some informal discussion accompanying the group's site visits to the various laboratories. However, I can only give you my impression that the group is asking searching questions and appears to be generally well impressed with the specific technical activities on which it has been briefed. Overall conclusions about the program and its future direction are likely to emerge, I believe, only in the final report that is scheduled to appear next January.

Question 3. Unfortunately, the Armed Services Committee allocated $15 million of this amount to the KMS Fusion, Inc. for operation expenses related to ICF research in support of the national laboratories and $4.6 million to KMS to upgrade its laser equipments. Do you think it was wise for the Committee to have specifically earmarked funding for one particular research effort?

Answer. Earmarking of funds by laboratory has created problems for us ever since the inertial fusion line item was instituted in the fiscal year 1976 budget. We are left with very little flexibility to meet changing program needs. In the coming year we would have no flexibility to respond to recommendations of the Technical Review Group should the Department decide to do so. The KMS Fusion proposal for an upgrade of its laser capability was made directly to the House Armed Services Committee and was not reviewed by the DOE in context with the other technical program priorities.

Question 4. How does your department currently determine how the ICF monies are allocated to the facilities participating in ICF research? Does one particular laboratory suffer at the expense of another in this process?

Answer. In proposing to fund inertial fusion activities at about the $70 million level in fiscal year 1986, the Department has made two rather difficult decisions. First, it was decided that, in order to maintain the integrity of the IF program, the support laboratories would need a proportionally higher level of support since these laboratories do not have the large overall resources that would help them absorb steep cuts in a given year. Second, the national laboratory directors have each been allocated about a third of the remaining funds and requested to determine within each laboratory's priorities how much additional weapons research and development effort should involve the use of inertial fusion facilities.

At near-level-of-effort funding, as you suggested earlier, our program priorities are to maintain the HALITE/CENTURION effort, and accomplish critical NOVA experiments while bringing on line the Particle Beam Fusion Accelerator II at Sandia. If the budget comes in below the level you suggest, there will have to be still deeper cuts distributed over the lower priority activities.

POST-HEARING QUESTIONS AND ANSWERS
FROM SENATOR WENDELL H. FORD
FOR DR. TRIVELPIECE
Relating to
FY 1986 AUTHORIZATION HEARING
Before the
SENATE ENERGY AND NATURAL RESOURCES COMMITTEE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
MAY 9, 1985

Question 1: Under your present plans, when will there be a "plasma burn"—that is, a demonstration of sustained thermonuclear fusion in a man-made device? Please describe the plans you have to achieve this.

Answer: The February 1985 Magnetic Fusion Program Plan indicates the need for results from a burning plasma experiment by the late 1990's. Presently, we are endeavoring to identify the characteristics and cost of a long-pulse burning experiment that will fill the programmatic need.

For the past year, several U.S. laboratories have been evaluating the technical feasibility of achieving ignition and burn in a compact tokamak device. This ignition approach appears to lead to ignition and burn at the lowest cost. DOE has invited representatives of the European and Japanese fusion programs to participate in our evaluation of this ignition approach. Both U.S., Japanese and European scientists have concluded that ignition and burn should be possible in a compact tokamak device, and we are now undertaking more detailed studies for such a device. We are encouraged that the preliminary cost estimates for this compact approach are much lower than for the larger long-pulse device previously considered, approximately $200-300M if built at an existing U.S. fusion laboratory site. At its July meeting, the Technical Working Party of the Summit Working Group accepted the feasibility of achieving ignition in a compact device and urged the earliest possible start and completion of a U.S. ignition project in order to best support international fusion development. From the international point of view, it would be preferable to begin an ignition project in FY 1988, so that demonstration of plasma burn could occur in FY 1993 or FY 1994.

Question 2: What is your reaction to Rep. Mike McCormack's testimony in which he proposes a demonstration, at a DOE site, of the feasibility of plasma burn in a "small" fusion device. Please discuss your view of this proposal in detail. What DOE sites would be considered? What are the pros and cons of using a DOE site as compared to alternatives?

Answer: As we understand it, Rep. McCormack's proposal is for a government-funded facility to host a variety of industrially-funded fusion burn experiments. We are aware of tentative discussions of possible industrial interest in such experiments, should they prove feasible at some time in the future. However, while we are always open to consideration of such proposals, we consider the likelihood of real industrial interest in such a facility at this time to be small.

Lacking a specific proposal, it is not possible to specify site criteria.

Question 3: The proposed funding for the fusion program in fiscal year 1986 is almost a hundred million dollars less than the original Administration request for funds for fiscal year 1985. What changes are being made in the program to accommodate such a substantial drop in resources? Which contracts will be canceled? Are any facilities to be closed? Which ones? How will the reduction be distributed over elements of the program and over facilities (such as the national laboratories) that participate in the program?

Answer: The budget request for FY 1986 for the Magnetic Fusion Energy program provides for continuation of the program's revised strategy which was initiated in FY 1985. This revised strategy was implemented to recognize that the changed energy supply situation has led to a reduced urgency for the development of new energy technologies. The current strategy calls for maintaining a broad research and development program to supply the science and technology base required for fusion, while proceeding at a more deliberate pace with the operation of large projects.

Specifically, this has meant that operation of the Mirror Fusion Test Facility - B, at the Lawrence Livermore National Laboratory, has been postponed. The achievement of energy breakeven in a tritium plasma in the Tokamak Fusion Test Reactor at the Princeton Plasma Physics Laboratory has been delayed. The fusion technology development effort will be restricted to work needed for near-term experiments and fundamental fusion feasability issues. Several small facilities have had to be closed. For the most part, we have attempted to do this as phases of work are completed to avoid waste. The major reductions have taken place at national laboratories. I will include two tables which compare the FY 1986 request with the FY 1985 level. The first is by program element, the second is by major contractor.

FY 1986 Congressional Budget Request
Magnetic Fusion Energy Program
Activity Listing
(BA in Millions)

	FY 1985	FY 1986
Applied Plasma Physics		
Advanced Fusion Concepts........	$ 24.7	$ 26.8
Fusion Plasma Theory............	23.5	21.9
Experimental Plasma Research....	18.5	17.8
Nat. MFE Computer Network.......	19.2	18.0
Subtotal......................	$ 85.9	$ 84.5
Confinement Systems		
Toroidal Systems................	$ 162.0	$ 158.3
Mirror Systems..................	41.7	41.7
Subtotal......................	$ 203.7	$ 200.0
Development and Technology		
Plasma Technologies.............	$ 32.5	$ 28.4
Fusion Technologies.............	27.7	27.1
Fusion Systems Analysis.........	14.0	12.0
Subtotal......................	$ 74.2	$ 67.5
Planning and Projects		
Tokamak Fusion Test Reactor.....	$ 12.2	$ 0.9
Fusion Materials Irradiation Test Facility..................	3.0	0
Mirror Fusion Test Facility.....	40.7	20.0
General Plant Projects..........	9.4	9.1
General Purpose Equipment.......	3.8	4.0
Subtotal......................	$ 69.1	$ 34.0
Program Direction...............	4.1	4.0
Total Magnetic Fusion Energy.....	$ 437.0	$ 390.0

Office of Fusion Energy
(Dollars in Millions)
Budget Authority

	FY 1985 Estimate	FY 1986 Estimate
Argonne National Laboratory	$ 4.6	$ 4.0
Brookhaven National Laboratory	0.3	0.3
University of California, Los Angeles	5.2	4.4
GA Technologies, Inc.	39.0	39.2
Hanford Engineering Dev. Laboratory	5.3	2.4
Idaho Nuclear Engineering Laboratory	1.9	1.5
Lawrence Berkeley Laboratory	7.4	4.4
Lawrence Livermore National Laboratory	95.0	70.0
Los Alamos National Laboratory	19.7	14.4
Massachusetts Institute of Technology	25.5	27.0
Oak Ridge National Laboratory	66.7	62.2
Pacific Northwest Laboratory	0.2	0.1
Princeton Plasma Physics Laboratory	116.3	100.2
Sandia National Laboratory	4.7	4.5
Texas, University of	6.0	5.4
Wisconsin, University of	4.5	4.0
All Other	34.7	46.0
	$ 437.0	$ 390.0

Question 4: What thought has the Department given to how a fusion research, development and demonstration program might be structured to operate over several years at constant dollar funding of $300 million, $200 million, or $100 million annually? For each of these levels, describe the kind of program that would be feasible, including the facilities that would be employed, existing and in the future. Is there a threshold below which no such program would be viable?

Answer: Current planning for the program assumes that it will continue to be supported at approximately the same level of effort as requested for FY 1986. Assuming substantial scientific input from the European and Japanese fusion programs, this level is adequate to prepare the essential scientific and technical base required for fusion by around the turn of the century. Since we believe that we have correctly identified the scientific and technical issues that must be resolved to make fusion a reality, any significant change from this would require a redefinition of the program goal as stated in the Magnetic Fusion Program Plan.

Reductions to the $300 million level would result in an accelerated loss of highly trained people and ineffective use of existing facilities. Furthermore, it would be difficult to replace obsolete facilities on a schedule to remain competitive with other world fusion programs. At this level, the U.S. would find it difficult to continue to take advantage of its present high level of international collaboration.

At lower levels of funding, the U.S. fusion program would become a marginal support activity for European and Japanese fusion development.

POST-HEARING QUESTIONS AND ANSWERS
FROM SENATOR PETE V. DOMENICI
FOR DR. TRIVELPIECE AND DR. R. SCHRIEVER
Relating to
FY 1986 AUTHORIZATION HEARING
Before the
SENATE ENERGY AND NATURAL RESOURCES COMMITTEE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
MAY 9, 1985

Question 1: Dr. Trivelpiece, we both know that you were cut by the Congress last year and given some conflicting signs as to what was expected as a result. I would just like you to know that I think turning the program away from energy applications towards basic research is a mistake. I do not think the Congress will support a budget of about $400 million for basic research in a specialized area like plasma physics. I think you have to have energy goals. Can you comment?

Answer: As you know, the Magnetic Fusion Energy Program is a long range energy research and development program, with a strong scientific component. However, it always has been and still remains a goal oriented energy program. The current emphasis is on developing the science and technology needed to achieve that goal as well as developing innovative new ideas. We have also begun to look at less expensive options for an ignition experiment in response to Congressional direction. The budget reductions have been accommodated by decreasing effort on certain long term technology development activities and proceeding at a more deliberate pace with our large projects. We believe at this point in the development cycle of fusion it is appropriate to emphasize the scientific and technological development which is essential to any future applications.

Question 2: Dr. Trivelpiece, you have two proposed upgrades for experimental machines. In both cases you intend to pay for them out of existing funds for operations. I guess that means you expect people to be layed-off while these projects are under construction. Is this your normal practice? How can you run the machine once you have upgraded it?

Answer: We are concerned about maintaining the vital scientific staff in areas of the programs that require improved experimental facilities. Nonetheless, within available budgets, the new devices must be funded by decreasing operation of obsolete facilities.

During the current period of economic stringency, fusion program laboratory managers are using a number of resourceful techniques to maintain their essential scientists during fabrication periods. Beyond those project needs, other temporary staff assignments can be identified to usefully employ critical personnel. These include assignments to other fusion labs, other assignments within the same laboratory, and participation in international exchanges. This approach has proven successful recently when new or modified devices at Oak Ridge National Laboratory, Princeton Plasma Physics Laboratory, and the University of Washington were funded from the operating budget.

I believe these same techniques will be successful at Los Alamos, and that the vital scientific staff will be retained so that this staff will then be available to lead the research on the new device.

Question 3. Dr. Schriever, we finally have a formal review underway which will give us some outside perspective on the ICF budget. I guess it is none too late because OMB has done it again by cutting the request in half. I am sure the Congress will restore some of these funds and permit these machines -- in which we have a huge investment -- to complete their experimental programs. My question is, how will your outside review group properly judge the operation of the Sandia machine which will not be finished until 1986, if it is to report by early 1986?

Answer. The full capabilities of PBFA II will in any case not be known for several years. Initial target experiments are scheduled to begin early in fiscal year 1988, and that schedule may prove to be optimistic. The review group has at its disposal a pretty well documented record of performance of the predecessor machines, PROTO I and II and PBFA I. You may be aware that Sandia's pulsed power program has been periodically reviewed by an panel that was formerly chaired by Al Trivelpiece and more recently by Ron Davidson, and that Dr. Davidson and one of two other members of that laboratory-sponsored review panel are also members of the current NAS group. I appreciate your concern but believe that, with this background, the current review group can evaluate fairly the potential of pulsed power technology in the context of the total inertial fusion program.

Question 4. There have been some very optimistic press reports recently about the particle beam machine. The results of focusing experiments have been so good that there is talk about reaching "break-even" conditions. I am somewhat conservative about this because I remember such talk in the late 70's which said we would be there today. Can you fill us in on their accomplishments?

Answer. The focusing experiments at very low voltage are quite promising. PBFA II is, technically speaking, a couple of generations in advance of the PROTO I machine on which these results were obtained. We may know by the end of fiscal year 1987 how well these results translate to the larger and more advanced machine. In addition, there are other technical issues, such as switches for getting out the short pulse required by the target and a number of approaches to providing the ion source, that need to be resolved favorably before we can judge the machine's performance. You need a lot of enthusiasm at the technical level just to attack such problems. The results so far are gratifying. Still, I think the program Sandia has laid out to characterize the machine's performance over most of 1986 and 1987, and proceed thereafter with two to three years of target experiments, is consistent with the caution you rightly invoke.

Question 5: A question for both of you.--Why don't we do more to get input from utilities on these programs. It is my understanding that some groups think ICF holds more promise for utility application than magnetic fusion. Similarly some groups tell me that the large TOKAMAK is not the way to go with magnetic machines. They say we need smaller machines. Can you comment?

Answer: The Electric Power Research Institute, whose members are utility companies, offers the possibility of involving utility planners with our programs. The Atomic Industrial Forum is another avenue for exchange of views. Their planning horizons, I believe, extend now to the first decade of the next century. For energy, our perspective is somewhat longer. However, our program perspective in inertial fusion is primarily the nuclear weapons program and its research needs in the next 10 to 20 years.

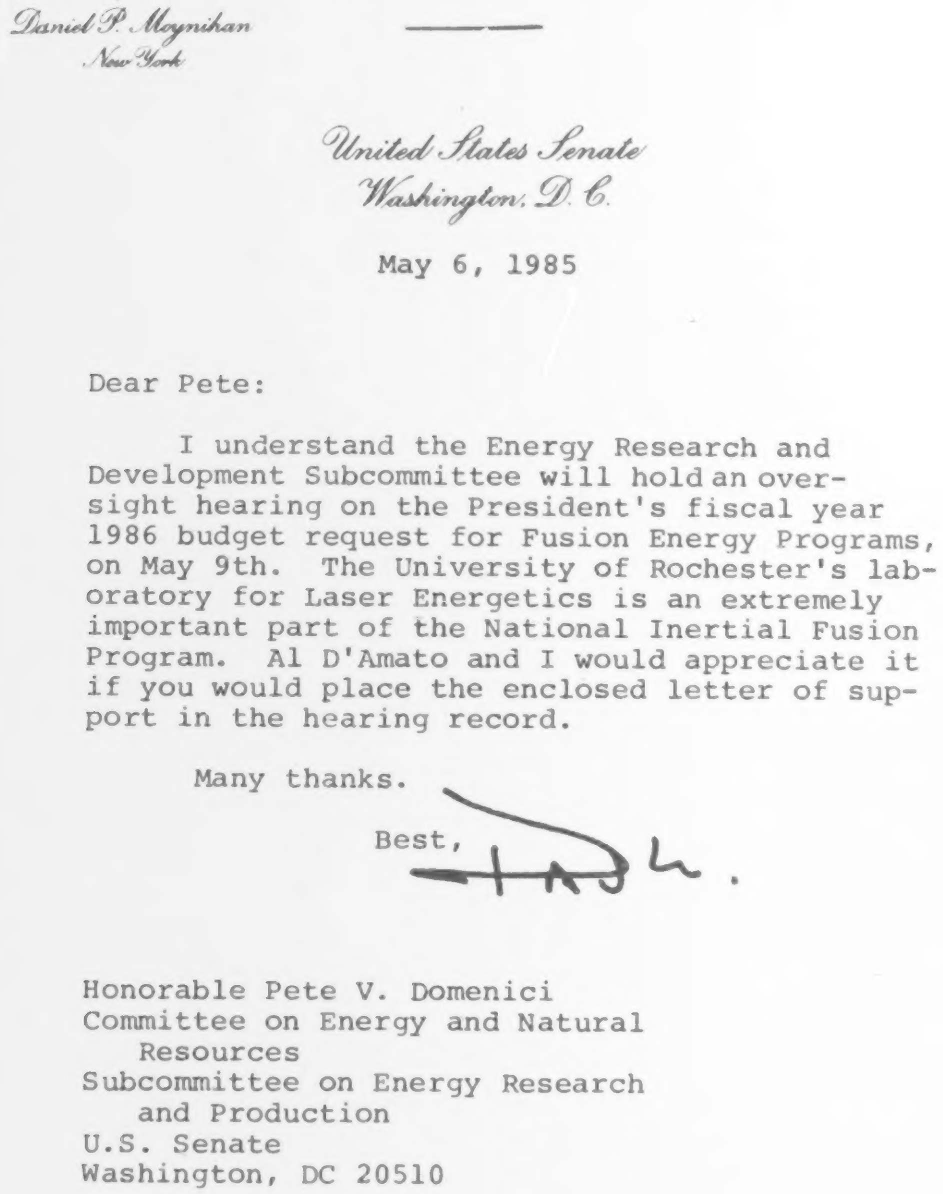
There are many arguments about scale and complexity for end users of controlled fusion. Nevertheless, most of us tend to expect that the ignition devices, both magnetic and inertial, would be rather large because they would be optimized for scientific verification rather than for energy extraction. Obviously, nature likes fusion to occur on a large scale. It remains to be seen how small the scale can be and how much the complexities of the first ignition device can be reduced. Once ignition and gain are demonstrated, I believe that the costs of large and expensive facilities will drive us to scale down and simplify -- and even to find alternative approaches we cannot now see -- well before fusion is commercialized . If we didn't think that both magnetic and inertial fusion offer unique, though in some cases still uncertain, advantages, we surely would not be pursuing both approaches.

The magnetic fusion program does have and has had good communications with the utilities by interaction with the EPRI Fusion Power Systems Program Committee, by utility representatives serving on magnetic fusion program study, review, and advisory committees. The magnetic fusion program actively solicits input from the utilities. Staff from the Magnetic Fusion Energy Program are presently discussing the possibility that EPRI personnel will become even more involved in magnetic fusion program activities.

The different opinions on the most appropriate form for the ultimate fusion reactor reflect the uncertainty both in our scientific and technological understanding of fusion but, also the uncertainty with respect to the competitive energy situation which might exist after the turn of the century. The most balanced and informed opinion of our advisory groups is that a balanced research program is needed to provide the technical base for resolving the technical uncertainty of fusion while the other real world issues of energy economics and environmental acceptability of other energy systems are being resolved.

APPENDIX IV

ADDITIONAL MATERIAL SUBMITTED FOR THE RECORD



Daniel P. Moynihan
New York

United States Senate
Washington, D.C.

May 6, 1985

Dear Pete:

I understand the Energy Research and Development Subcommittee will hold an oversight hearing on the President's fiscal year 1986 budget request for Fusion Energy Programs, on May 9th. The University of Rochester's laboratory for Laser Energetics is an extremely important part of the National Inertial Fusion Program. Al D'Amato and I would appreciate it if you would place the enclosed letter of support in the hearing record.

Many thanks.

Best,

Honorable Pete V. Domenici
Committee on Energy and Natural
Resources
Subcommittee on Energy Research
and Production
U.S. Senate
Washington, DC 20510

United States Senate
WASHINGTON, DC 20510

May 9, 1985

Dear Mr. Chairman:

We wish to comment jointly on the importance of the University of Rochester's Laboratory for Laser Energetics in the National Inertial Fusion Program. As you recall, we wrote you last year, urging support for the University's program to complete the conversion of the OMEGA laser system to ultraviolet light. Thence, the Laboratory for Laser Energetics could fulfill its vital mission in the National Program by providing laser-matter interaction data, capsule physics, diagnostic development, and laser optical engineering. We do appreciate the action taken by the Congress for FY 1985, supporting this valuable program.

This year we wish to remark on the potentially adverse consequences of the U.S. Department of Energy's change in the status of Inertial Confinement Fusion (ICF), from a separate program office under a civilian Assistant Secretary for Defense Programs to a program in the Office of Military Applications. There are no apparent technical or programmatic justifications for reducing the budget of the ICF program to approximately 45 percent of its FY 1985 budget, as contemplated by the Administration. Presently, the National Academy of Sciences (NAS) is reviewing the National ICF Program, as requested by the Congress. The Congress should not accept the Administration's view that this program needs less support while the NAS review is in progress. Neither should the Congress drastically change the structure of the ICF program at this time. We urge that the Congress permit the program to continue while working with the NAS Technical Review Group and the U.S. Department of Energy to arrive at a consensus for the future of ICF.

The program in ICF has been making excellent progress; the technical data from the completion of the NOVA laser system at Livermore and the frequency-converted, ultraviolet OMEGA system at the University of Rochester are now becoming available. In order to make the best use of these facilities, the ICF budget must be restored to last year's level.

In this critical time of budget deficits it would be inappropriate to endorse excessive growth in the ICF Program, but we do urge that a level-of-effort in the short-wavelength laser program be maintained so the national program can meet its objectives and milestones. Dr. Schriever, Director of the U.S. Department of Energy Office of Inertial Fusion, stated in Senate testimony last year that, "In the laser fusion area, the most important breakthrough has been the development of efficient wavelength conversion now being implemented on NOVA and OMEGA." The United States must take advantage of the investment in the conversion breakthrough if we are to maintain our international lead in inertial fusion. Inertial fusion is vital to the Nation's nuclear weapons research in the near-term, and is extremely promising as a potential attractive energy source in the future.

The University of Rochester's Laboratory for Laser Energetics has signed a new 3-year Cooperative Agreement with the U.S. Department of Energy for a $23,468,000 program of continued research in the Defense Inertial Confinement Fusion Program. Additionally, the University operates the National Laser Users Facility (NLUF) which provides the only unclassified resource for researchers from other institutions to conduct experiments in intense laser-matter interactions. In the Cooperative Agreement, the level-of-effort program (consistent with FY85) will require $7,764,400 for operations in FY86, exclusive of funds to be provided directly to the NLUF users by the Department of Energy. If $750,000 are authorized and appropriated for NLUF users, a total authorization and appropriation of $8,514,400 is required.

We urge that a level-of-effort planning budget be incorporated in this year's authorization and appropriation. The laboratory has continued to meet its program milestones in inertial fusion. The recently converted OMEGA system, with its reliable high-repetition rate capability, can now be used to accumulate the data necessary to understand the physics scaling laws of inertial fusion, using a direct-drive symmetric illumination configuration. With the investment that has been made, we can study the effect on performance of changes in target size, laser energy and wavelength.

Results of recent experiments at Rochester give renewed promise for the successful demonstration of laser fusion. The Rochester facility has an excellent record of providing a wealth of high-energy-density physics data, atomic physics data, and x-ray laser physics data important to the National program. The Laboratory has conducted joint experiments with a number of national laboratories. In a current collaboration with the Los Alamos National Laboratory, for example, important knowledge is being generated which supports the long-term development of KrF as a laser fusion driver.

Additionally, it is important that abrupt changes in funding for continuing University research projects be avoided wherever possible, when those projects produce excellent and important results for the Nation. The LLE mission to help educate and train scientific leaders is essential to the inertial fusion effort. More than 200 students have received graduate and undergraduate training at LLE, 41 of whom have received their Ph.D. degrees. These students are now making significant contributions in the National laboratories, industry, and universities.

Attached for your information is a report of the latest milestone reached at the LLE. Just last week the OMEGA system tripled the world's highest recorded energy yield for ICF. We hope that you find this information useful, and we look forward to working with you on other issues of importance.

Sincerely,

Daniel Patrick Moynihan

Alfonse M. D'Amato

Honorable Pete V. Domenici
Committee on Energy and Natural Resources
Subcommittee on Energy Research and Production
United States Senate
Washington, DC 20510

KMS FUSION, INC.
3621 SO. STATE STREET
P. O. BOX 1567
ANN ARBOR, MICHIGAN 48106

ALEXANDER J. GLASS
PRESIDENT & CHIEF OPERATING OFFICER

313/769-8800
TELEX 23-5237

15 May 1985

Senator Pete V. Domenici
Chairman
Senate Subcommittee on Energy Research and Development
SD-317
Dirksen Building
Washington, D.C. 20510

Dear Senator Domenici:

I want to thank you for inviting me to appear before your committee on 9 May 1985. Unfortunately, the inertial fusion program is currently undergoing a review by the National Academy of Sciences, and the requirements of preparing for a visit by the review panel to KMS Fusion prevented me from participating in your committee's hearings.

I enclose my written testimony for inclusion in the committee record. Thank you for inviting me to testify to your committee.

Yours sincerely,

Alexander J. Glass/jp
Alexander J. Glass
President

enclosures

jp

xc: E. Sinclair
T. Liddy

STATEMENT ON INERTIAL FUSION RESEARCH

by

ALEXANDER J. GLASS
President, KMS Fusion, Inc.

Submitted to the U.S. Senate Committee on Energy and Natural Resources
Subcommittee on Energy Research and Development
9 May 1985

Summary

The 1986 Administration budget proposal calls for a 60 percent reduction in funding for the Inertial Confinement Fusion (ICF) program. With the Nova facility starting operation, and significant technical progress in the classified portion of the program, we feel that such drastic budget reductions are counter-productive, and will deprive the country of the benefits of the billion-dollar-plus investment made to date in the ICF program. KMS Fusion urges the committee to restore funding for the ICF program to a productive level.

KMS Fusion plays a unique role in the ICF program, as the primary source of classified physics data supporting the Nova experiments program, and as a major supplier of target technology. We propose to modify our laser facility, Chroma, to increase our capability to conduct ICF target physics and x-ray laser experiments. This enhancement will provide the program with a low cost, high data-rate facility for physics data, and will free up the $180 million Nova facility for the high-value ICF and weapons physics experiments for which it is uniquely suited. KMS Fusion requests a 1986 budget of $15 million in operating funds, and $4.6 million in capital equipment, to carry out the proposed facility modification, while continuing our research program.

The Inertial Fusion Program

Fusion is the process which generates the sun's radiant energy, and which gives the hydrogen bomb its awesome power. In fusion, the fuel, consisting of the heavy isotopes of hydrogen (deuterium and tritium), is heated to a temperature of 100 million degrees, hotter than the sun's interior. At this temperature, the hydrogen nuclei fuse together to form helium, with an attendant release of energy. The fuel must be confined, i.e., held together long enough so that the energy released exceeds the energy invested to heat the fuel to the reaction temperature.

Inertial Confinement Fusion (ICF) is one approach to confining and heating fusion fuel. Energy from a powerful laser or particle beam is concentrated on a spherical shell containing the fuel. The fuel is heated and compressed in the process, until thermonuclear conditions are achieved at the center, igniting the fusion reaction. The surrounding compressed fuel is then ignited by a propagating thermonuclear burn wave, releasing energy from the fusion reaction.

Inertial Fusion research has been supported by the Congress for over a decade, with two objectives. In the near term, the ICF program provides information about thermonuclear physics which is of vital importance to the nuclear weapons program. In the long term, ICF is viewed as an alternative path to harnessing fusion as a source of energy. In the Department of Energy, the ICF program is administered by the Office of Inertial Fusion, under the overall direction of the Assistant Secretary for Defense Programs.

The hydrogen bomb demonstrates that inertial fusion is feasible on a large scale. The objective of the ICF program is to demonstrate that thermonuclear ignition can be achieved on a laboratory scale, driven by a laser or particle beam. The ICF program has constructed three major facilities to assess the feasibility of inertial fusion. These are Antares, a 40 kilojoule carbon dioxide laser at the Los Alamos National Laboratory, Nova, a neodymium-glass laser producing 100 kilojoules of infrared light, at the Lawrence Livermore National Laboratory, and PBFA-II, a light-ion beam facility currently nearing completion at the Sandia National Laboratory.

Last year, Congress called for a high-level review of the ICF program by the administration. A prestigious panel of scientists has been assembled, under the auspices of the National Academy of Sciences, to conduct this review. They met here in Washington early in March, and heard presentations from the Office of Inertial Fusion, and from each of the six participating laboratories. The panel will visit each of the ICF laboratories in the weeks to come. The NAS review committee is scheduled to submit an interim report this summer, and a final report by February 1986.

The Nova Project

In 1979, the Department of Energy approved the construction of the Nova laser at LLNL. Nova was originally conceived as a 20-beam, neodymium-glass laser, capable of generating 200-300 kilojoules of infrared light in three-billionths of a second (3 nanoseconds). However, DOE only approved construction of a ten-beam system, designed to produce 100 kilojoules of infrared light, but with frequency conversion capability, to convert the output to visible light. The total project cost for Nova is approximately $180 million. Nova can operate either with two beams or ten, and is equipped with two experimental target chambers.

There are two basic approaches to driving an inertial fusion target. The laser light can impinge directly on the target (direct drive), or can be converted to x-rays in an enclosure ("hohlraum") containing the fuel mass, and the x-rays used to drive the target (radiation drive). Radiation-driven targets offer better uniformity of illumination than direct-drive targets, but sacrifice efficiency at lower laser energies. Both approaches are currently under investigation in the ICF program. Nova experiments will emphasize the radiation-driven approach, which also provides important information on the physics of nuclear weapons.

In order to ignite the fusion reaction, it is necessary to heat the fuel to 100 million degrees, and to compress it to 1000 times the density of liquid hydrogen (1000 x L.D.). Nova experiments are unlikely to achieve both conditions simultaneously. However, it is expected that targets will be compressed to 500 x L.D. in the first year of Nova's operation, at a temperature lower than that required for ignition. Subsequent Nova experiments are expected to achieve 1000 x L.D., at sub-ignition temperatures. Data from the Nova experiments, taken together with information obtained from other sources in the program, will define the driver and target requirements for both ignition and high-gain targets.

These experiments will thus provide the basis for evaluating the applicability of ICF to both its military and energy objectives, in the 1986-1987 time frame.

KMS Fusion's Contributions to the ICF Program

KMS Fusion is located in Ann Arbor, Michigan, and is the only private participant in the ICF program. KMS Fusion has played a major role in the development of inertial fusion. The company began fusion research in 1971. Ten years ago, the world's first successful demonstration of laser-produced thermonuclear reactions took place at KMS Fusion's laboratory, in Ann Arbor, Michigan. Since then, the company has contributed many other innovative "firsts" to the program. KMS Fusion was the first to carry out experiments with short wavelength light, a technique which has been subsequently adopted world-wide. The company pioneered the use of frozen (cryogenic) fuel in ICF targets, a complex technique generally acknowledged to lead to improved target performance. Until 1983, when LLNL conducted its first cryogenic target series, KMS Fusion was the only laboratory in the world to carry out cryogenic experiments. KMSF scientists had demonstrated, in 1981, that cryogenic targets perform better than gas-filled targets. Most recently, in 1983, the company developed a multi-frame holographic interferometer for visualizing the evolution of material surrounding the surface of a target. This instrument is capable of providing stop-motion images in a fifty-billionth of a second. Up to four such images can be recorded during each experiment, which lasts less than a billionth of a second.

The company is a major supplier of targets and target components within the ICF program. The target fabrication effort comprises roughly half of the company's activities. This effort supports the internal research program at KMS Fusion, and also produces target materials and components for the other participants in the program. Several European laboratories also buy the sub-millimeter-sized glass Microshell fuel containers that KMS Fusion has developed for fusion use. In addition to target fabrication, the company is pursuing long-term research to develop the large targets needed for the critical experiments to be performed on Nova. These targets involve several techniques and technologies developed at KMS Fusion, including cryogenic fuel, and various new target materials.

In addition to the company's efforts in material science and target fabrication, KMS Fusion operates a highly productive experimental facility, the Chroma laser. Chroma is a two-beam laser, capable of producing up to 800 joules of infrared light in a pulse of one billionth of a second duration. This energy can be efficiently converted to visible light, which couples more effectively to the fusion target. The laser is equipped with a pulse stacker, which allows us to synthesize pulses of arbitrary temporal shape, an important parameter for optimal target compression. The Chroma laser is outfitted with three experimental areas. This allows us to carry out one set of experiments, while setting up other experimental configurations. At present, one experimental area is devoted to a unique optical system, devised and patented by KMS Fusion, which enables us to illuminate a target uniformly from all directions, using the light from the two beams of Chroma. Either gas-filled or cryogenic targets can be imploded in this target chamber. The other experimental areas are used to explore the physics of radiation-driven targets, and to conduct other experiments on laser-matter interaction.

KMS Fusion's Unique Role in the ICF Program

In 1979, KMS Fusion was designated as a support laboratory for glass laser experiments, and since then, its efforts have been closely coordinated with those of the lead laboratory for glass laser experiments, LLNL. About 850 experiments were carried out on the Chroma laser facility in 1984. KMS Fusion is the only laboratory other than LLNL conducting glass laser experiments on radiation-driven targets. With its highly flexible experimental facilities, operating at a high data rate, and backed up by a full spectrum of capabilities in data analysis, target design, target fabrication and diagnostic instrumentation, KMS Fusion has emerged as the primary source of supporting physics data for the "flagship" facilities at LLNL, Nova, and its predecessor, Novette.

Experiments are carried out at KMS Fusion by our scientific staff, often with the involvement of researchers from LLNL and other laboratories. Over the last two years, LLNL-KMSF teams have conducted experiments on the use of x-ray spectroscopy to diagnose the density and temperature of target plasmas, the effect of classified target construction on hot electron generation, and the characterization of x-ray sources used for target analysis. In preparation for the historic experiments conducted at LLNL last year, which demonstrated soft-x-ray laser action for the first time, joint LLNL-KMSF-NRL experiments were conducted on the Chroma facility to establish which candidate materials were most likely to succeed in an x-ray laser experiment, and how the plasma cloud surrounding the target would evolve. Our internal research program is also directed toward providing the physics and technology data base required for the proposed Nova experiments. During the past two years, we have measured the transport of energy in target plasmas, using spherical illumination, which creates nearly one-dimensional target conditions which are much more readily analyzed; and we have developed and applied novel diagnostic techniques to measure the distribution of energy and the occurrence of deleterious plasma processes in hohlraum targets. We have continued to pioneer the development of cryogenic targets, and have recently solved the difficult problem of stabilizing a uniform layer of liquid D-T in a large, Nova-sized target.

KMS Fusion maintains a small effort on the development of the Oxygen-Iodine laser. If energy can be extracted from that laser efficiently in a short pulse, it could provide the required combination of short wavelength, high repetition rate and high efficiency required for all ICF applications. Over the past two years, we have received support for further development of this laser from NASA, and the Air Force Weapons Laboratory.

We requested funds in FY 1985 to initiate the design and construction by KMS Fusion of a cryogenic target facility for the University of Rochester. During the summer of 1984, the University of Rochester asked us to accelerate that project, to allow us to deliver the finished target assembly to them early in Calendar Year 1986. By redirecting a portion of our program funds, we were able to satisfy their request. Our cryogenic technology will be installed on the Omega laser facility at the University of Rochester during the first quarter of 1986, and will be ready for operation at that time.

KMS Fusion's 1985 Budget Request

As in previous years, all the participants in the ICF program look to Congress to restore program funds deleted in the Administration's budget request. At the $70 Million level proposed by the Administration, we cannot operate the facilities that exist in the program, and therefore cannot progress toward the program goals. It is doubly ironic that we are confronted by the spectre of a disastrous budget cut just as the Nova facility starts operation, and as the National Academy's review committee starts its deliberations. For several years, KMS Fusion has testified before Congress that a modest increase in KMS Fusion's funding would enhance the productivity and cost-effectiveness of the ICF program, especially in the use of its premier facility, Nova. As we have noted in this testimony, our facility, with its flexibility, full spectrum of supporting services, high data rate and low operating cost, is ideal for conducting those experiments which do not require the full capability of the facilities at the national laboratories, but which provide the data base needed to ensure the success of the high-value experiments carried out on the large facilities.

In 1986, we are proposing to modify our laser, Chroma, to increase its output from its current level of 500 joules of visible light to 2500 joules, in a one nanosecond pulse. We have provided the committee with a detailed proposal for this modification, which is a classified document. We request that our proposal, which has been submitted to the committee staff, be incorporated into the record. This modification will entail a one-time capital cost of $4.6 million. In addition, we are requesting operating funds of $15 million.

We feel that this modification is extremely important in view of the climate of cost consciousness which surrounds these hearings. The modified Chroma laser would continue to operate at a shot rate of 6-10 shots per day, with only minor increases in operating costs. At a rate of 850 shots per year (our actual 1984 shot rate), and a five-year lifetime, with an operating cost estimated to be $4 million per year, the total cost of an experiment on the modified Chroma will be about six thousand dollars. For the sake of comparison, the corresponding figure for a Nova shot will be over $200 thousand.

Of course, Nova will produce twenty times the energy of the modified Chroma. As a result, LLNL will be able to carry out experiments which cannot be conducted on any other facility. These must be high-value experiments in target implosion physics, weapons physics, and weapons effects. In our classified proposal, we show that many of the supporting experiments involving energy transport, laser-plasma interactions, and x-ray laser development can be carried out on Chroma at far lower cost, making Nova available for those experiments to which it is uniquely suited.

We propose to continue operating Chroma while the modification is underway. We do not expect the changeover to the modified system to interrupt our experimental schedule for more than about one month. We shall continue our work on target fabrication, supplying targets and target components to the other laboratories in the program, on diagnostic development, and on the development of the Oxygen-Iodine laser.

In a period of heightened cost-consciousness, the true measure of economy lies in enhanced productivity. Cutting the program funding in half is disastrous, because it reduces the productivity to zero. The funding level which we request will truly be cost-effective, both by increasing the utility of the KMS Fusion facility, and by enhancing the productivity and availability of the Nova laser.

Testimony submitted to Senate Energy Committee
Energy Research & Development Subcommittee
on the
FY 1986 Magnetic Fusion Energy Budget

by

Dr. Tihiro Ohkawa, Vice President

GA Technologies, Inc.

GA Technologies has accumulated the broadest base of experience in magnetic fusion of any industrial concern in the world. Paralleling the history of the field, GA's involvement in fusion research progressed from primitive benchtop experiments in the 1950's and 1960's to today's sophisticated devices that themselves are an important driver of advanced technology. Thirty years of dedication to the harnessing of fusion power has given me some insight into the proper direction for the magnetic fusion program.

The present technological leadership of the United States is due in large measure to the breadth and depth of our nation's scientific base. The Magnetic Fusion Energy Program does good science and contributes in a significant way to honing high-technology skill in a variety of disciplines. Although recent adverse budgetary developments will of necessity delay the schedule for developing a fusion energy option, there has been no compromise in the integrity of the science. Indeed, the program is now structured to insure that a secure scientific base exists prior to making key program decisions. This is as it should be. Given the status of existing energy supplies, the need for a fusion energy option is perhaps two or three decades away unless environmental or political "events" demand an earlier implementation. This permits a reasoned judgement on the confinement approach best suited for end-use applications. Such a reasoned judgement requires both strong theoretical underpinnings and a confirmation of the theory in plasmas that approximate end-use conditions.

The Magnetic Fusion Program Plan prepared by the Department of Energy identifies this search for the optimum confinement systems as the key technical issue for magnetic fusion. For the next few years, the bulk of the program resources will be devoted to this undertaking. The tokamak approach will be used as the spearhead to access new regimes while alternative confinement approaches will be used to pinpoint the dependence of the science on the details of the magnetic geometry.

Today, the fundamental shortcoming of fusion science is the absence of data in a burning plasma, defined as a plasma that is sustained by the fusion fire. Because fundamentally new science may emerge from a burning plasma experiment, such a step is an inescapable program element. Unfortunately, the dynamics of such a process cannot be simulated in existing devices, in which the plasma is sustained by sources of power under the control of the experimentalist.

Thus a new machine is required. Only the tokamak is sufficiently advanced to meet this challenge in the near term. The highest priority of both the tokamak experimental effort and the technology development effort should be to provide confirmation of the design decisions. The continuous string of advances in the tokamak program make me very confident that such a process would lead to a successful burning plasma experiment.

By isolating the burning plasma issue from a number of nuclear technology objectives, the cost of the experiment can be kept to a manageable level. The proper perspective to view the cost issue is expressed in the Magnetic Fusion Program Plan in the phrase "to provide the broadest understanding at minimum cost", a theme that I wish to elaborate upon.

Because the critical program need is the understanding of the physics of a burning plasma, it is not enough for the device to perform a demonstration. The device must also be capable of yielding an extensive quantity of high quality data. Thus the design of the burning plasma experiment should incorporate the following feature, which would not be present in the demonstration alternative:

1. Access for a full complement of scientific instruments to measure and analyze plasma behavior.

2. Flexibility to explore a variety of operating conditions.

3. High availability, so that adequate operating experience can be obtained.

The last of these issues, that of availability, has the greatest cost impact. Of particular concern is the ability to keep state-of-the-art hardware in good working condition when faced with the complexities of remote maintenance. I firmly believe that we should not cut corners in areas that govern the definitiveness with which burning plasma physics can be investigated. The price for the understanding to be gained is a wise investment in the future of fusion research.

Turning to broader program issues, I wish to state my support of the Magnetic Fusion Program Plan. It offers a sensible strategy for a balanced, but somewhat slower-paced, program to harness thermonuclear power. The FY 1986 Magnetic Fusion Energy Budget submitted is the minimum level required to keep the program logic intact. Continuing to make progress in the face of two consecutive cuts from the FY 1984 budget level is reflected in two new elements of program strategy embodied in the Magnetic Fusion Program Plan. The first is a reduced emphasis upon future large facilities which simultaneously serve major scientific and technological missions. This is exemplified by the present conception of the burning plasma experiment, where the technology is regarded as subservient to the scientific mission and the cost constraints.

The second new element of program strategy is increased reliance upon international cooperation. While I find great appeal in the potential benefits of international cooperation, our reliance upon it should not extend to abrogating technical responsibility in any of the research areas that are critical to the fusion energy option. We may choose to accomplish individual program steps via joint ventures but we must remain self-reliant in all the key scientific and technological disciplines. After all, who would want to cooperate with us if our capabilities were inferior to their own. The burning plasma experiment is a natural candidate for international cooperation. The United States must take the initiative in such a venture, however. The preferred approach is to commit to such a project and bring in partners to expand the program scope.

I wish to close by pointing out the remarkable parallelism between the existing program at GA Technologies and the program structure embodied in the Magnetic Fusion Program Plan. Our largest program element is Doublet III, now in the midst of conversion to DIII-D, a large D-shaped tokamak. DIII-D will play a pivotal role in preparation for a burning plasma experiment. The search for the optimal magnetic geometry is the major GA program focus, both through DIII-D and through OHTE, a confinement idea recently pioneered by GA that has already had a number of significant experimental successes. Although less seasoned than the tokamak approach, OHTE shares with other high power density approaches the advantage of a shorter product cycle. Thus, advances in the science could trigger major program strides in a relatively brief period. Further evidence of the similarity between the GA program and the blueprint for the national effort is the central role played by international cooperation. Indeed, the cooperative agreement with the Japan Atomic Energy

Research Institute for joint research on Doublet III is the largest cooperative fusion venture yet undertaken by the United States.

To reiterate the substance of my message: by following the strategy outlined in the Magnetic Fusion Program Plan, we can conduct a high quality, productive research program at the budget level submitted. Further budget erosion would strike at the core of the program logic. We should begin now to plan for a burning plasma tokamak experiment, building on existing program resources. Accomplishing such a project by international cooperation has appeal if the United States takes the leadership role.

Your continued strong support of the magnetic fusion program is greatly appreciated.

DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS—FISCAL YEAR 1986

(Nuclear Energy Programs and Nuclear Waste Activities)

MONDAY, MAY 13, 1985

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:12 p.m., in room SD-366, Dirksen Office Building, Hon. Pete V. Domenici presiding.

Present: Senators Domenici, McClure, Warner, Hecht, Evans, Johnston, and Ford.

Also present: Paul Gilman, professional staff member; Benjamin S. Cooper, professional staff member for the minority; and James T. Bruce, counsel for the minority.

OPENING STATEMENT OF HON. PETE V. DOMENICI, A U.S. SENATOR FROM THE STATE OF NEW MEXICO

Senator DOMENICI. Good afternoon. Today we have Mr. James Vaughan, Acting Assistant Secretary for Nuclear Energy Programs at DOE, and Mr. Ben Rusche, Director of the Office of Civilian Radioactive Waste Management. They're here to present testimony on the Department's budget request for these areas.

We also have representatives from the GAO to answer relative questions and we will conclude with a panel of four witnesses. We'll try to expedite the hearing in order to accommodate the witnesses and Senators, but we do have a couple of hours this afternoon so we ought to be able to get most of the work done.

Mr. Vaughan, we'd be happy to hear your testimony. Are you ready to start?

Mr. VAUGHAN. Yes, I am, Senator.

Senator DOMENICI. All right. Do you want to move that mike over a little bit closer?

Oh, excuse me. Did any of the Senators have anything they'd like to say by way of opening statements?

Senator FORD. I don't have a statement, Mr. Chairman. I do have several questions and I'll just save the time for the questions, if you don't mind.

Senator DOMENICI. Thank you very much, Senator.

All right, we'll proceed.

STATEMENT OF JAMES W. VAUGHAN, JR., ACTING ASSISTANT SECRETARY FOR NUCLEAR ENERGY, DEPARTMENT OF ENERGY, ACCOMPANIED BY DR. LYLE WILCOX, DEPUTY ASSISTANT SECRETARY FOR BREEDER REACTOR PROGRAMS, DEPARTMENT OF ENERGY; JOHN BAUBLITZ, DIRECTOR, REMEDIAL ACTION PROJECTS, DEPARTMENT OF ENERGY; AND JOHN LONGENECKER, DEPUTY ASSISTANT SECRETARY FOR URANIUM ENRICHMENT, DEPARTMENT OF ENERGY

Mr. VAUGHAN. Mr. Chairman and members, I am pleased to be here today to discuss the Department's nuclear fission energy and uranium enrichment programs. Our written statement provides a detailed description of each element of the programs and our fiscal year 1986 budget that supports them, so therefore I'll confine my remarks to highlighting some key aspects.

Senator DOMENICI. Your statement will be made a part of the record, Mr. Vaughan.

Mr. VAUGHAN. To provide an overview as to where we're coming from in our nuclear energy program, we need to note that nuclear power has indeed proven to be a safe, reliable, environmentally acceptable energy source that currently is providing about 14 percent of the electric power in this country.

Progress in the past year has been good. But even with the conservative forecasts of our increasing demand, we are going to need new generating capacity not currently on order before the turn of the century.

I think we all know that the nuclear energy option is in serious danger of being foreclosed for a variety of interrelated reasons, both institutional and management, and that our international leadership in the nuclear energy technology area is eroding.

I think it's fair to say that both Government and industry share responsibility for this problem. We're taking aggressive action to help correct it. The Department of Energy is committed to doing its share.

Consistent with the administration's energy policy goals, the continued use of both coal and uranium, which are our principal domestic resources for competitive electricity production, will be needed to meet our goal of providing a balanced, diverse, secure energy supply at reasonable cost.

First I will talk about our civilian reactor development programs which are aimed at meeting these goals for the near term, intermediate term, and long term. Our funding request for this year is $350 million compared to $387 million appropriated in fiscal year 1985. For the near term, we are strongly committed to achieving needed reforms in the nuclear licensing and regulatory process. We're strongly committed to working closely with industry to enable the availability within the next 5 years of improved, standardized, light-water reactor designs, state of the art technology that can be approved and certified by the NRC, and reduction in the utilities' risk in ordering these for deployment.

Our continuing light-water reactor research and development efforts, particularly those related to safety, source term, and severe accident evaluations, including our efforts at Three Mile Island, are directly supportive of and essential to achieving these goals.

For the intermediate term, our current technology needs to be augmented to meet the alternative needs for advanced converter reactor designs. There are a number of common features in this effort: a variety of size options; a potential for more modular factory fabrication and reduced capital investment; more passive safety features; continuing application of high technology features that simplify plant operation and reduce the chances for operator error; and lastly, simplified and accelerated licensing.

We have restructured our advanced reactor development program and are critically evaluating innovative light-water-cooled, gas-cooled, and liquid-metal-cooled reactor designs, including reviewing with the NRC, safety and licensing features under their new advanced concepts program.

We would intend in fiscal year 1987 to come to you with a more focused plan to narrow the alternatives, compare their technical and economic merits, and enable development of reactor system with proven attributes that hopefully could qualify for private sector support of a demonstration effort by the mid-1990's.

For the longer term, beyond the year 2000, we continue to believe that we will need to extend our uranium resources and that that will require both the continued use of advanced converter reactors and at at some time the introduction of breeder reactors, just as France, West Germany, and Japan are doing.

For that reason, our continuing breeder technology program is aimed at that objective; and this effort is essential to maintain our leadership in liquid metal and in fuels and materials technology, and to enhance our international collaboration. Our key test facilities, with which a number of you are familiar are essential to that effort.

Our proposed fiscal year 1986 civilian reactor development budget has already been constrained and trimmed to a minimum consistent with the administration's objectives. We need and appreciate the continuing support of this committee to achieve those objectives.

If I could turn for a moment to our advanced nuclear systems and defense-related nuclear energy systems portion of the budget, our Advanced Nuclear System Program is funded at $20 million in fiscal year 1986 to support a number of civilian and military needs for small power systems called radioisotope thermoelectric generators. Since the first use of these unique power sources in the early 1960's, they've supported a number of key missions, and in fact in some cases have been essential for a variety of these applications. Our fiscal year 1986 efforts will include enabling power for NASA's Galileo and Ulysses launches.

There are two other defense-related nuclear energy development efforts that are included in our fiscal year authorization request as it has been amended in early April, and both of these involve cooperative shared funding with other agencies.

The first of these is the so-called SP–100 Program at $17 million in fiscal year 1986, which is a triagency program initiated in 1983 involving Department of Energy, Department of Defense, and NASA. Our goal is for a class of nuclear power sources up to 500 kilowatts electrical that would support a broad range of military and civilian missions in the 1992–95 timeframe. This summer we plan to be selecting a single concept for continued testing over the next 4 or 5 years as a part of the ground engineering system demonstration program. One of the first uses for this nuclear reactor source will likely be a space-based radar system.

The second program in this category is the north warning power project, funded at $2.5 million in fiscal year 1986. This reactor will meet needs for ground-based power sources that can operate continuously in harsh environments with a minimum of attendance by people and freedom from the logistic train associated with diesel oil for diesel generators.

Our Department, along with the Air Force and Atomic Energy of Canada, Ltd., are funding a program to demonstrate the feasibility of a 15-kilowatt electric reactor source along the upgraded north warning system, which used to be called the distant early warning line. We anticipate placing a demonstration reactor in ground testing by early fiscal year 1987 and the placement of prototype reactor shortly thereafter.

The next phase of our programs in this authorization bill are under the category of nuclear waste technology and remedial actions. These are not all strictly research and development activities, as you well know, but are within that category of the budget. These remedial action efforts are a significant factor in our efforts to maintain public trust and confidence in the nuclear option. The Department does take very seriously its responsibilities to perform those actions to clean up the environment within the several programs covered in this appropriation. We've established what we believe are appropriate priorities on the basis of contamination levels and proximity of public activities to the remedial action sites. We are proceeding at a reasonable and technically acceptable pace to accomplish these goals.

The major remedial action activities are unchanged from last year, including the formerly utilized sites remedial action project; the project at Grand Junction, CO; the Uranium Mill Tailings Remedial Action Program for inactive mill tailing sites; the Surplus Facilities Management Program; and the demonstration of decontamination and solidification of high-level radioactive waste at West Valley, NY.

Our fiscal year 1986 budget request for these programs is $233 million. That's an increase of $73 million over our fiscal year 1985 level, but about $20 million below our prior outyear projections. The activities last year and this year in these projects have been characterized by overall program planning, preparation, and establishing agreements with the various States, Indian tribes, and municipalities.

We have initiated work at the highest priority sites and increases in the annual funding levels are needed in fiscal years 1986 and 1987 as we move from the planning and engineering stages to the actual performance of work at these sites.

Because of the Department's strong commitment to completing these cleanup efforts, we have elected in balancing our budget priorities to continue these programs at levels only slightly below previous outyear funding projections, rather than maintaining them at the lower fiscal year 1985 funding levels. To have chosen that latter course, we believe, would have entailed unnecessary delays in completing many of the projects, with resulting increase in the total cost to the Government.

The progress has been good on a number of these remedial action projects. Senator Domenici and I had the pleasure last November of participating with the Navaho Nation in dedicating the effort at Ship Rock, NM, which was a real plus in starting the work at one of the higher priority sites the first on Indian land.

I'd like to now turn to the last of the program categories, the subject of uranium enrichment. We believe that a strong domestic uranium enrichment capability is also essential for the future of the nuclear option. As I think all of you know, our enrichment enterprise has faced the problems of excess capacity, reduced demand, and severe foreign competition.

During the past year the Department has taken significant steps to restore the strength of the enrichment enterprise. First, we've converted over 90 percent of our sales base to new utility services contracts. Second, we remain committed to serving our customers better, communicating with them more effectively, and conducting the enterprise in a competitive manner.

Third, we have also recently completed an incentive pricing effort that will increase our fiscal year 1987–90 volume by about 14 percent over previous levels, which will enable us to offer lower prices to our customers.

Fourth, we have improved the overall economy of operating our gaseous diffusion plants. The average energy cost of producing each separative work unit is down 10 percent as a result of shifting operations to the source of cheapest power. We plan further reductions in the coming year through increased use of off-peak power.

Last, we are completing an intensive evaluation to select a single advanced enrichment technology for a more focused development and reliability demonstration. This should lead to deployment of that advanced technology when it becomes prudent to invest in lower cost capacity to further reduce our production costs.

As in the past, our funding request for the uranium enrichment program will have to be fully offset by projected revenues. In addition to the advanced technology selection decision, we're facing some tough choices regarding whether to continue operations in all three of the gaseous diffusion plants, the question of deployment of gas centrifuge enrichment plant, and allocation of our research and development funds.

In addition this year, we must also allocate for payback to the Treasury for past net appropriations in accordance with the recent Senate budget resolution. We will be formulating and providing to you and other key committees additional budget details as these decisions are made in the near future, but we do continue to believe that we can achieve key program objectives and satisfy them within a net zero appropriation.

In the interest of brevity, Mr. Chairman, that concludes my opening remarks.

[The prepared statement of Mr. Vaughan follows:]

STATEMENT OF
JAMES W. VAUGHAN, JR.
ACTING ASSISTANT SECRETARY FOR NUCLEAR ENERGY
DEPARTMENT OF ENERGY
BEFORE THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON ENERGY AND NATURAL RESOURCES
U.S. SENATE

MAY 13, 1985

Mr. Chairman and Members of the Subcommittee, I am pleased to be here today to discuss the Department of Energy's nuclear fission energy and uranium enrichment programs. The nuclear fission energy programs include our reactor development programs as well as waste technology and remedial action programs. The FY 1986 budget request in support of these programs is summarized in the following table:

Program Element	FY 1986 Request ($ in Millions)
Civilian Reactor Development	
Improved Light-Water Reactor Technology	$ 53.3
Advanced Converter Reactor Technology	105.2
Advanced Breeder Reactor Technology	141.3
Water-Cooled Breeder Reactor Technology	19.7
Civilian Reactor Development Support	30.5
Advanced Nuclear Systems	20.0
Subtotal	370.0
Nuclear Waste Technology and Remedial Actions	
Nuclear Waste Technology	11.7
Remedial Actions	233.0
Subtotal	244.7
Uranium Enrichment Activities	
Power	884.0
Enrichment Research and Development	150.0
Gas Centrifuge Enrichment Plant	340.0
All Other	238.7
Total Expenditures	1,612.7
Uranium Enrichment Revenues	-1,612.7
Net Uranium Enrichment	0
Net Energy Supply Research and Development Appropriation	614.7
Defense Nuclear Energy Programs	19.5
TOTAL REQUEST	$ 634.2

NUCLEAR FISSION ENERGY PROGRAMS

STATUS OF THE NUCLEAR OPTION

An essential ingredient of our Nation's economic growth is the assured availability of an adequate supply of energy at a reasonable cost. Over the past four decades, consumption of electric power has increased more rapidly than the Gross National Product. With even the present rate of growth, significant new electrical generating capacity will be needed in the 1990's to sustain a competitive industrial economy.

Consistent with the President's Nuclear Power Policy statement of 1981 and with the Department's National Energy Policy Plan (NEPP-IV), nuclear energy should remain an essential element in the national policy goal to provide a balanced, diverse source of energy supply at reasonable cost. Coal and uranium are our two principal indigenous energy resources for competitive electricity production, and both will be needed to meet this goal in the near- and long-term.

Nuclear energy currently plays a prominent role in meeting this Nation's anticipated energy demands. It is a safe and reliable energy source, currently providing nearly 14 percent of the electricity consumed in the United States. In 1984, domestic nuclear powerplants generated more than 340 billion kilowatthours of electricity. There are 89 operable[1] commercial nuclear powerplants in the United States. By 1990, if most of the plants currently under construction are completed, light-water-cooled reactors in this country will supply about 18 to 20 percent of our electricity and will represent an investment of several hundred billion dollars.

The other side of the coin is disappointing. There have been no new orders for nuclear reactors since 1978, and the utilities have cancelled 115 orders for nuclear plants since 1972. The absence of additional orders means that the last operating nuclear powerplant in the United States could be shut down before the year 2030, based on currently estimated plant lifetimes. Our position of technical leadership and the ability of U.S. industrial suppliers to compete in the international market are threatened. Further, the international leadership of the United States in nuclear energy technology -- a U.S. invention -- is eroding.

In short, the nuclear energy option is in serious danger of being foreclosed; despite the fact that over the past 25 years nuclear power has proved to be a reliable, economical, and environmentally acceptable provider of electricity; and despite the fact that nuclear power has an excellent safety record.

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[1] An "operable" nuclear powerplant is one that has received the full-power amendment to its operating license and is allowed to operate at full power.

Nuclear powerplants have become unacceptable economic risks that discourage private investment. These high economic risks are due primarily to an unpredictable licensing process, construction delays, and high capital costs. This in turn has led to a reduced acceptance of nuclear power by the utilities, the financial community, and the public.

In this situation, should we, as some have suggested, abandon our nuclear energy research and development program and just put the current nuclear technology on the shelf for use when it is needed in the future? There are several cogent reasons why this will not suffice.

The first is that current technology, as good as it is, must be augmented to meet the intermediate and longer term needs of the Nation. Today's large light-water-cooled nuclear powerplants represent capital investments that are too great for some utilities, their control and safety systems are complex, and their construction is too expensive and lengthy. In addition, one or more of a new generation of advanced light-water-cooled reactors, high-temperature gas-cooled reactors, and liquid-metal-cooled reactors, embodying the best of available high technology, should be available in the 1990's to enable the nuclear industry to provide utilities and other users with less expensive, more quickly constructed sources of power with improved economics and enhanced passive safety features. Beyond the year 2000, the need to extend our uranium resource will likely require both the continued use of advanced converter reactors and the introduction of breeder reactors. Accordingly, the development programs have been restructured to ensure retention of nuclear power as a viable technical and economic option for consideration by the marketplace.

A second reason is that the same institutional impediments that are currently inhibiting private investment in nuclear power will continue into the future unless we actively and cooperatively seek solutions today. Chief among these impediments is the unpredictable and lengthy licensing process. Most nuclear plants now take 12 to 14 years from time of order to full-power operation. This should be reduced to 6 years or less. The extra licensing and construction time costs the utilities, and eventually the ratepayers, millions of dollars annually. The Department strongly supports the enactment of comprehensive licensing reform legislation aimed at remedying this situation without compromising the assurance of public health and safety.

Thirdly, even the best of technologies cannot be effectively utilized without the industrial infrastructure and skilled personnel necessary to make it work. Unless changes are made soon to facilitate the ordering and licensing of commercial nuclear plants, the capability of the United States to produce high-quality reactors will diminish significantly, and the supply of highly skilled nuclear scientists, engineers, educators, and technicians will dwindle.

What is needed is a cooperative effort among the nuclear industry, the utilities, and Government, for the purpose of completing designs of advanced plants using state-of-the-art technology, and obtaining certification of those designs. This, coupled with a stable and predictable licensing and regulatory process, would permit utilities to order "standard," or fixed-design plants suitable for multiple site applications, with reasonable economic risk. Then, if the plant is built to specifications, it could be operated without undue delay and, thereby, reduce costs on invested capital.

The Department's principal role in this near-term effort would be that of a catalyst -- not an investor or subsidizer -- to help foster a concerted effort to ensure that nuclear power will be a viable option for the market now and in the future. Through cooperative efforts between industry and Government, removal of the disincentives that have caused nuclear power to become an unacceptable economic risk would enable a new reactor plant order in the near term. Our mutual goal should be to create an environment in which the private sector will be willing to order an advanced-design nuclear powerplant by about 1990.

The advanced LWRs currently being designed by the United States nuclear industry in conjunction with foreign partners for licensing and deployment overseas offer an excellent near-term opportunity to begin solving many of the problems described above. Much of the requisite technology exists from over 30 years of experience. Several evolving designs provide greater tolerance to abnormal events and, thus, longer operator response times without unacceptable safety risks. Our efforts will concentrate on stimulating industry to transform these designs into reality and to seek cooperative solutions to many of the institutional problems that beset the industry.

In parallel, the Department plans to pursue a continuum of development of advanced nuclear fission technology for the future. History teaches us that the effective application of any basic technology requires both continuing deployment and experience concomitantly with focused research and development to enable improvements in the future. The Department has an historic and valid continuing role in nuclear safety research, as well as in the enabling of advanced nuclear technologies.

With this background, I would like to describe the Department's reactor development programs that address these problems.

CIVILIAN REACTOR DEVELOPMENT

The cancellation of the Clinch River Breeder Reactor Project has afforded the Department an opportunity to reshape our nuclear reactor research and development programs. In so doing, we have taken the best elements of our existing programs and refocused our efforts more on the near- and intermediate-term needs of the country. There is an increased emphasis on innovative means to meet those needs, and we have a closer coordination among all program elements to assure the most effective use of limited resources.

An additional feature of our program is increased emphasis on international collaboration. Sharing of operating experience, research results, and facilities with our technical partners overseas could result in safer and more economical nuclear systems. Increased international collaboration, particularly in costly test facilities and projects, can help restore credibility to the United States as a nuclear trading partner and strengthen our position in international commerce. The Department will assess the possibilities for enhanced collaboration between the United States, Japan, and Western Europe in several reactor development programs.

Likewise, effective nonproliferation progress requires that the United States remain a major, reliable, and credible international supplier of nuclear fuels, services, and equipment. Our influence over other nations in the use and control of nuclear materials will be sharply limited if we cease to maintain our professional and technical leadership in nuclear power.

The Civilian Reactor Development program comprises the areas of Improved Light-Water-Cooled Reactor Technology, Advanced Converter Reactor Technology, Advanced Breeder Reactor Technology, Water-Cooled Breeder Reactor Technology, and Civilian Reactor Development Support. The funding for each of these program areas is summarized in the following table:

Program Element	FY 1986 Request ($ in Millions)
Improved Light-Water Reactor Technology	$ 53.3
Advanced Converter Reactor Technology	105.2
Advanced Breeder Reactor Technology	141.3
Water-Cooled Breeder Reactor Technology	19.7
Civilian Reactor Development Support	30.5
Total	$ 350.0

Improved Light-Water-Cooled Reactor Technology

The Improved Light-Water-Cooled Reactor Technology program is directed at performing generic research and development, building on current designs, that requires a long-term effort using the unique capabilities of Government facilities, and at performing research and development associated with the recovery from the accident at Three Mile Island Unit 2. Efforts will be focused on extending plant lifetimes; enhancing safety; improving licensability, operation, and reliability; and helping to place emergency planning criteria on a rational technical basis.

The Department continues to apply its unique experience and technical resources to the efforts at the Three Mile Island site. In return, the experience that we have gained and the technology developed will be of generic benefit to the Government and to the entire nuclear industry. Removal of loose fuel debris is scheduled to begin at Three Mile Island in July of this year. Major Department activities in FY 1986 will include examination of portions of the damaged reactor core and development activities associated with removal of the several tons of fuel known to be in the bottom of the reactor vessel and in the reactor coolant system. This research and development work will contribute directly to the objectives noted above. In parallel with these technical efforts, the Edison Electric Institute has implemented a plan by which the Nation's utilities will provide General Public Utilities Nuclear Corporation $150 million toward the cost of the cleanup at TMI-2.

Advanced Converter Reactor Technology

The Advanced Converter Reactor Technology program is a key element of our technological efforts. This program includes work on three principal nuclear systems:

- Advanced, innovative light-water-cooled reactors
- Advanced liquid-metal-cooled reactors
- Advanced high-temperature gas-cooled reactors.

Work on all three of these systems has a common set of objectives:

- To significantly improve system economics
- To develop passive safety features
- To increase tolerance to abnormal events
- To shorten construction times
- To facilitate licensing.

We must marry the best of U.S. industrial technology with improved reactors in varying size ranges if we are to foster a revitalization of the nuclear option. Each of these reactor types has the potential to achieve these objectives. Our planned FY 1986 design and testing efforts will focus on selecting the best features, evaluating tradeoffs, and narrowing our choices for continued development and potential testing of key features and safety capabilities. Continuing interaction with the Nuclear Regulatory Commission for initial licensing review of the advanced reactor designs is an inherent part of this effort.

Technology for the next generation of innovative water-cooled reactors will be developed in close cooperation with industry. The Department, in conjunction with the Electric Power Research

Institute (EPRI), will evaluate proposed advanced light-water reactor concepts and assess passive safety features with the potential for reducing licensing-related delays in construction. One focus will be to evaluate and select designs of medium-sized light-water-cooled reactors that utilizes state-of-the-art technology and innovative design features to overcome many of the current problems. Emphasis will be placed on standardized design, increased factory fabrication, reduced cost and licensing time, enhanced safety margins, and improved reliability. Specific tests will be identified to verify innovative features supporting these objectives.

In the area of Liquid-Metal-Cooled Converter Reactor Technology, we have already taken the first steps toward innovative design approaches. We have selected two U.S. reactor design organizations to work under contract to DOE to develop advanced concepts for smaller, modular liquid-metal-cooled reactors of less than 300 MWe output, that offer the advantages of more complete factory fabrication and ease of shipment. Delivery to the plant site of a completed module of standard design could make possible a construction period of only 3 to 5 years from time of order to full commercial operation. This would reduce interest expense, shorten the planning horizon, and permit utilities to enter plant costs into the rate base earlier.

We anticipate that the relatively detailed conceptual designs being developed in this 3-year effort will provide a focal point for this program element and will also focus related research and development work. Designs for passively safe liquid-metal-cooled reactors can provide one of several options for advanced and alternative converter reactor designs to be used in the next 10 to 20 years.

High-temperature gas-cooled reactors have a variety of unique and attractive features which can provide greater safety and larger investment protection margins. These include the use of an inert helium coolant, a core with high heat capacity and low power density, and the capability to operate at very high temperatures. Additionally, these reactors have the potential to meet industrial requirements for process heat (as oppposed to electricity generation). During 1985, a single reference design for a small, modular high-temperature gas-cooled reactor will be selected as the basis for continuing detailed design and development of the requisite technology base in FY 1986 and beyond.

Expansion of our international collaboration in high-temperature gas-cooled reactor programs is also planned. The United States will continue to implement the agreement with the Federal Republic of Germany under the Umbrella Agreement in Gas-Cooled Reactor Technology. Planning is also underway between the

United States and Japan on a cooperative program in technology development.

Advanced Breeder Reactor Technology

The Advanced Breeder Reactor Technology program has been significantly restructured since the cancellation of the Clinch River Breeder Reactor Project. We currently have no funding directed to large-scale demonstration projects in this program. Instead, the program is funded and paced to maintain the breeder as a viable option for deployment in the 21st century.

The current breeder reactor program remains a key link with significant international breeder development and fuel cycle programs, particularly in Japan, France, the Federal Republic of Germany, and the United Kingdom. It is essential that we not underestimate the importance of these ties. These nations are moving toward deployment of breeder reactors on an earlier timetable than we are, because of their differing energy supply circumstances. This presents us with both a unique challenge and a unique opportunity.

The challenge is to further international nonproliferation goals -- goals for which we remain a leading proponent -- even though the United States is no longer leading the deployment of breeder technology. The opportunity is one of being able to capitalize on our past expenditure of resources and our technology leadership in reactor fuels and materials, to obtain overseas operating experience, and thus to reduce future expenditures while maintaining a viable, active breeder option for future deployment.

To be successful in both endeavors requires that we consolidate and extend our technology base and expand our collaborative international agreements. It is essential that we maintain a consistent, albeit reduced, effort in this area to preserve our domestic breeder option for the next century, as well as to restore our credibility in the international arena. The FY 1986 breeder reactor program will actively pursue this objective. One key element in this program is the initiation of the long-lived core demonstration experiment to be fabricated at Hanford and tested in the Fast Flux Test Facility (FFTF).

Water-Cooled Breeder Technology

The objective of the Water-Cooled Breeder Reactor program is to develop technology that will improve the efficiency of nuclear fuel resource utilization. Activities in FY 1986 will include the continuation of work associated with the light-water breeder reactor (LWBR) core recently removed from the Shippingport power station, including examination and evaluation of selected fuel elements from that core for "proof of breeding."

Summary of Civilian Reactor Development Program

In summary, nuclear technology must continue to be an important component of this Nation's balanced and mixed energy system. We must be prepared to offer the marketplace a nuclear option that continues to be safe, technically sound, and publicly accepted, with a stable and predictable licensing and regulatory process. Our nuclear energy programs seek to ensure that there will be safe and economical reactors and fuel cycle technologies, so that private industry can select the best options to meet needs that we cannot entirely predict today.

Closely coupled with our development efforts, however, is the need for Government and all elements of the industry to address the institutional impediments to continued viability of the nuclear option. We need to reform the licensing process through legislative and administrative means, foster the use of standardized (i.e., fixed) designs, permit U.S. suppliers to compete equally in foreign markets, and restore our credibility in the international arena. Only through these initiatives can we ensure attainment of the national energy policy objective of an adequate supply of energy at reasonable cost.

Attainment of these objectives is a prerequisite to realizing the significant benefits of our investment in past, present, and future research and development efforts. The economic well-being and energy security of the Nation depend upon our success.

ADVANCED NUCLEAR SYSTEMS

I would like now to describe our Advanced Nuclear Systems program and comment briefly on some related activities.

The Advanced Nuclear Systems program, to be funded at $20 million in FY 1986, supports civilian and military applications of nuclear energy in space exploration through the development of a range of nuclear power systems. As resources permit, we also intend to pursue other advanced technologies under this program. To date, the program has provided the Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA) with radioisotope thermoelectric generators (RTGs) that have been used successfully as the power source for 23 space missions and numerous terrestrial applications. Since the first use of these unique power sources in the early 1960's, nuclear energy has been found suitable, and in some cases essential, for a variety of such applications.

Two primary goals have been established for the Advanced Nuclear Systems program. The first goal is to provide the technology base to meet civilian and military requirements for RTGs in present and future space and terrestrial applications. The second goal is to build and develop flight-qualified RTGs to support specific missions.

The focus in FY 1986 is on those activities related to the NASA Galileo and Ulysses spacecraft launches in 1986 and on the continuation of environmental testing and safety reviews, which are a cornerstone of the Department's responsibilities. We plan to continue advanced development work as resources permit.

The planned NASA launches of the Galileo and Ulysses spacecraft in May/June 1986 will highlight our major activities for this fiscal year. We will complete the assembly and testing of isotope power units and deliver the units to the NASA Kennedy Space Center. We will also support the launches and make certain that safety documentation and safety testing are complete. Continuation of the environmental and safety testing efforts is vital. To assure that we can meet the power performance requirements of the NASA missions, thermal vacuum testing of the qualification isotope-fueled unit will continue throughout the year at the Mound Plant, and life testing of the electrically heated engineering unit and the 18 couple modules will continue at the General Electric facility. Long-term testing information is crucial to our ability to forecast the performance of the flight units.

DEFENSE NUCLEAR ENERGY PROGRAMS

Planned activities for higher-power, defense-related nuclear energy sources are extensions of ongoing efforts. Our funding request for defense-related nuclear energy programs in FY 1986 is $19.5 million, as compared to the $11.4 million appropriated in FY 1985. These are cooperative and shared programs with Department of Defense (DOD) user agencies, wherein DOE is carrying out its reactor development responsibility consistent with the Atomic Energy Act. An increasing number of defense activities, including the President's Strategic Defense Initiative, involve applications of nuclear energy sources at power levels beyond those achievable with conventional radioisotope thermoelectric generators (RTGs).

Two significant efforts are involved in our FY 1986 budget request:

- The SP-100 space reactor program, which would supply power to a variety of civilian and military missions, and

- The North Warning Power Project, which is a potential alternate power supply for the planned modernization of the Distant Early Warning (DEW) line across northern Canada.

Both of these activities also have supporting funds requested by user agencies in FY 1986, as well as current funds in FY 1985.

SPACE REACTOR TECHNOLOGY (SP-100)

The SP-100 program is a tri-agency program involving the Department of Energy (DOE), the Department of Defense (DOD), and the National Aeronautics and Space Administration (NASA). The goal of the program is to establish the feasibility of developing a 100-kWe class (up to 500 kWe) reactor power system that would enable a broad class of military and civilian missions in the 1993-95 time frame and beyond. The program was initiated in February 1983, and it has been planned as a three-phase effort. The first phase is focused on the evaluation of various concepts and the establishment of technical feasibility. The second phase will focus on the ground engineering systems test of one concept selected in mid-1985, at the conclusion of the first phase. The third phase will involve flight qualification and will proceed when a specific mission commitment has been made. In addition, scoping efforts have been and will continue to be conducted on higher power multimegawatt reactor systems for civilian and military space missions in future years.

DOE's contribution to the jointly funded SP-100 program has historically been provided through the Energy Supply Research and Development Appropriation. The evolution of the program indicates that the first application likely will be for a military mission. There is also a possibility that this reactor may be used on the second National Aeronautics and Space Administration space station. As the program proceeds into the Ground Engineering System phase, the Strategic Defense Initiative Office (on behalf of DOD) and DOE have assumed the lead roles in the program. Accordingly, DOE funding for the Ground Engineering Test phase should be provided in FY 1986 to enable our continuing role in reactor systems development.

Early in the first phase of this project, as a result of evaluating a large number of concepts for reactor and heat transport systems, three concepts were selected for technology assessment and feasibility demonstration. These include an in-core thermionic concept being pursued by General Atomic and Martin Marietta, a fast-spectrum, lithium-cooled reactor, thermoelectric concept being investigated by General Electric, and a lower temperature reactor, Stirling cycle concept being evaluated by Rockwell. The concept selected will be ground-tested as part of the Ground Engineering System program to begin in FY 1986.

The site for the ground test will also be selected in mid-1985. The ground test program is projected to require 5 to 6 years, and it is expected that progress will be sufficient to allow a flight commitment by the 1988-89 time period.

There are a broad range of potential mission applications, but one of the most likely first uses will be with a space-based radar system. Such a system could require power in the range of 100-200 kWe and could require a launch as early as 1992-93. Other potential applications could encompass the entire spectrum of space endeavors, from communications and surveillance to orbital transfer propulsion, space stations, future planetary and lunar missions, and support for the President's Strategic Defense Initiative.

NORTH WARNING POWER PROJECT

Turning now to terrestrial applications, I would like to focus on the North Warning Power Project. There is a military need, and possibly even a civilian need, for ground-based power systems that can operate continuously in harsh environments with minimum attendance and freedom from the need for frequent replenishment of fuel supplies such as diesel oil. These systems must have high reliability, low maintenance, long lifetimes, and simplified logistics. Nuclear reactor technology appears to offer feasible and improved alternatives to conventional power systems.

The current reference power supply is a diesel system; however, the logistics and resupply costs of maintaining diesel generators have led to consideration of a reactor power system as an alternative. Because such a system would require only minimum maintenance, it would potentially result in significant savings in operation and maintenance costs and, eventually, in overall life cycle costs. Therefore, an assessment of the concept was undertaken in FY 1984. Based on the positive findings of that assessment, conceptual design efforts on the North Warning Reactor were initiated in FY 1985. The Department of Energy, the United States Air Force (USAF), and Atomic Energy of Canada, Limited (AECL), are jointly funding a program to investigate and demonstrate the feasibility of using a 15-kWe reactor power source for radar station applications in the North Warning System (formerly called the Distant Early Warning Line).

The reference design consists of a passive reactor core that uses heat pipes to transport heat from the core to thermoelectric elements, which convert the heat to electricity. Basically, all of the system components use state-of-the-art technology that has been used in other systems. For example, the nuclear fuel will consist of pellets of the type used in high-temperature gas-cooled reactors. An organic Rankine heat conversion system is being considered in order to increase efficiency and reduce both capital costs and overall life cycle costs. The initial objective of the program is to place a demonstration reactor in ground testing by early FY 1987. This will be followed by the placement of a prototype reactor, such that a decision on full-scale deployment could be made as early as 1988.

NUCLEAR WASTE TECHNOLOGY AND REMEDIAL ACTIONS

I would like now to discuss the Nuclear Waste Technology and Remedial Action programs. Although the Remedial Action programs are not research and development oriented, they are included in our budget request for fission energy programs.

Our Nuclear Waste Technology funding request for FY 1986 is $11.7 million in budget authority, as compared to the $13.0 million appropriated in FY 1985. The FY 1986 budget request for the Remedial Action program is $233.0 million, an increase of $73.0 million over the FY 1985 appropriation. The funding for each program element appears under each program.

Before providing an overview of these programs, I want to assure you that the Department takes very seriously its responsibilities to perform remedial actions to clean up the environment within the several programs covered in this appropriation. This work is important and necessary to correct the legacies that, in many cases, have been left over from programs completed a number of years ago at sites which are no longer actively in use. We have established appropriate priorities for these programs on the basis of contamination levels and the proximity of public activities, and we are proceeding at a reasonable and technically acceptable pace to accomplish these goals. At the same time, we are continuing our monitoring and surveillance activities to assure that none of the sites will create a health or safety hazard for people in surrounding areas.

FY 1984 and 1985 activities in a number of these projects have been characterized by overall program planning, engineering preparation, and establishing cooperative agreements with the States, Indian tribes, municipalities, and industrial concerns involved at the various sites. In addition, work has been initiated at the highest priority sites. In accordance with prior planning, and to maintain the schedule for this work, increases in annual funding levels are needed in FY 1986 and FY 1987, as we move from the planning and engineering stages to the actual performance of work at additional sites.

Accordingly, because of the Department's strong commitment to completing these cleanup efforts, we have elected, in balancing our budget priorities, to continue these programs at levels only slightly below previous outyear funding projections rather than maintaining them at lower FY 1985 funding levels. To have chosen the latter course would have entailed unnecessary delays in completing many of the projects, with resulting increases in the total costs to the Government over the period of work.

NUCLEAR WASTE TECHNOLOGY

The funds requested for Nuclear Waste Technology are distributed among the program elements as follows:

Program Element	FY 1985	FY 1986
	($ in Millions)	
Low-Level Waste	$ 6.2	$ 4.8
Waste Treatment	6.3	6.4
Program Direction	0.5	0.5
Total	$13.0	$11.7

The goals of the Nuclear Waste Technology program are (1) to help in facilitating the development of a nationwide system, through a series of regional compacts, for managing low-level wastes (LLW) and (2) to develop technologies for treating and immobilizing nuclear fuel cycle wastes.

The Low-Level Waste program provides technical assistance to States in developing regional capabilities for the disposal of low-level radioactive waste, in accordance with Public Law 96-573, the Low-Level Radioactive Waste Policy Act. The Waste Treatment program conducts research on high-level, transuranic, and sodium-contaminated wastes and develops and transfers technologies for the treatment and immobilization of spent nuclear fuel in forms that are suitable for transportation, storage, and ultimate disposal in a geologic repository.

Low-Level Waste

The Low-Level Radioactive Waste Policy Act assigned to the States the responsibility for disposal of low-level wastes generated within their borders, with the exception of wastes generated as a result of certain Federal activities. The formation of regional compacts to carry out this responsibility was encouraged by the Act. The goal of the Department's Low-Level Waste program is to assist States and regions in the development of an effective nationwide low-level waste management system by 1988, and to evaluate the system in terms of operational efficiency by 1990. The Department anticipates that Congress will be asked for its consent to the formation of between three and eight regional compacts in 1985.

During FY 1985, the Low-Level Waste program is providing technical asistance to States and regions for the development of new disposal facilities and for plans to stabilize and close disposal sites no longer in operation. The Department will also continue to assist Congress in its review of proposed regional compacts. DOE expects to finish development of the procedures that will be used to evaluate proposals for transfer of closed low-level waste sites to the Department under the provision of Section 151 of the Nuclear Waste Policy Act of 1982.

In FY 1986, the Low-Level Waste program will provide technical assistance to a limited number of States and regions to support the selection and development of new low-level waste disposal facilities; support the correction of problems and the stabilization at existing disposal sites; and complete an assessment of advanced, innovative methods for the treatment and disposal of low-level waste.

Waste Treatment

The major objective of this program is to complete the final phase of development of the process and system for immobilizing high-level wastes in a borosilicate glass waste form. A vital part of the effort is learning how to produce canisters of this waste in glass that will meet storage and repository disposal requirements. Technology transfer is being accomplished through close working relationships with other Departmental waste treatment programs, such as those at West Valley, New York; Savannah River, South Carolina; and Hanford, Washington. Activities in this progam are also coordinated with other Departmental efforts related to fuel reprocessing, generation of special wastes, transportation, and terminal isolation of high-level waste and spent nuclear fuel.

In the Waste Treatment program, we conduct the research and development necessary to reliably solidify high-level and transuranic wastes for transportation, storage, or disposal. Our major FY 1986 effort in waste treatment will be to complete the last phase of development of the process for incorporating high-level waste into a borosilicate glass form acceptable for disposal. In November 1984, the Department entered into a collaborative research and development project agreement with the Federal Republic of Germany on process controls and operation of a facility for solidification of high-level radioactive waste. As part of this exchange, the pilot-scale radioactive liquid-fed ceramic melter at the Pacific Northwest Laboratories at Richland, Washington, will be operated over a period of several months in FY 1985 and FY 1986. Approximately 20 to 30 canisters of radioactive borosilicate glass will be produced and subsequently used by the Federal Republic of Germany for testing purposes in their waste management program.

This testing and evaluation program is designed to demonstrate operability and maintainability in a remote radioactive environment. Also, equipment and process control correlations will be developed to produce high-quality glass products and to minimize the need for preoperational (nonradioactive) testing of future full-scale production systems. Additionally, a modest level of effort will be initiated in FY 1985 toward developing an acceptable second-generation high-level waste form that will be more cost-effective, accommodate higher waste loadings, and perform satisfactorily at the higher temperatures. Transuranic waste treatment technology will continue to be evaluated on a limited basis. Criteria and guidance for shallow land burial of sodium-contaminated wastes were completed as scheduled in FY 1984, and a final program report will be issued in FY 1985.

FY 1986 will mark the second year of the effort to determine the operational reliability, remote maintainability, safety, and process control flexibility of the ceramic melter system for solidification of high-level radioactive wastes. Efforts will continue on the development of a series of melter system design, testing, operation, and decommissioning handbooks for purposes of transferring this technology both to the private sector and to other government organizations involved in waste solidification programs. Candidate materials and processes will be evaluated to develop a second-generation waste form for the disposal of less-aged high-level nuclear wastes anticipated after the year 2000. Three of the most promising candidate waste forms will be selected for further development. TRU waste streams typical of commercially generated wastes will be quantified, their relationship to high-level waste treatment solutions will be defined, and new or improved treatment technologies will be developed.

REMEDIAL ACTION PROGRAMS

The objective of the Remedial Action program is to treat or stabilize radioactive wastes and to perform decontamination and decommissioning at contaminated DOE sites and at legislatively authorized non-Government facilities and sites. The major activities are: (1) the Formerly Utilized Sites Remedial Action Project (FUSRAP); (2) remedial action at Grand Junction, Colorado (Public Law 92-314 as amended); (3) the Uranium Mill Tailings Remedial Action Project (UMTRAP) for inactive uranium mill tailing sites (Public Law 95-604); (4) the Surplus Facilities Management Program (SFMP), for certain radioactively contaminated DOE facilities declared surplus and resulting principally from civilian nuclear energy programs; and (5) demonstration of the solidification of high-level radioactive wastes at West Valley, New York, for final disposal (Public Law 96-368).

The funds requested for the Remedial Action program are distributed among the program elements as follows:

Program Element	FY 1985	FY 1986
	($ in Millions)	
Formerly Utilized Sites	$ 18.0	$ 17.7
Grand Junction	1.5	0.9
Uranium Mill Tailings	62.0	110.0
Surplus Facilities	29.5	39.0
West Valley Demonstration Project	47.9	64.0
Program Direction	1.1	1.4
Total	$160.0	$233.0

Formerly Utilized Sites Remedial Action Project (FUSRAP)

FUSRAP provides for remedial actions at former nuclear processing facilities, now privately owned, which became radioactively contaminated as a result of Manhattan Engineering District or Atomic Energy Commission activities and which have not been decontaminated sufficiently to meet current public health and safety guidelines. FUSRAP also includes contaminated sites specifically assigned to DOE by Congress for remedial action.

To remedy the situation at these contaminated sites, either the contaminated material will be stabilized in place, with restrictions placed on the use of the site, or the contamination will be removed and disposed of at another location. Authority currently exists, derived from the Atomic Energy Act of 1954, for conducting remedial actions at 20 sites, based on a review of the involvement of the Department's predecessor agencies in activities at these sites. In FY 1984, this review process led to the addition, by the Department, of the following 5 sites (included in the total of 20) to the project: Ashland sites 1 and 2 (Tonawanda, New York), the Seaway landfill (Tonawanda, New York), Mallinckrodt (St. Louis, Missouri), and W.R. Grace (Curtis Bay, Maryland). Review of other sites involved in past activities of the Department's predecessors is continuing and may result in the addition of other sites to the program.

Congress added four new sites (Maywood, New Jersey; Wayne/Pequannock, New Jersey; Colonie, New York; and Hazelwood, Missouri) and $5.0 million in the FY 1984 Energy and Water Development Appropriation Bill, with direction to initiate a decontamination research and development project at these sites as a priority action.

In the FY 1985 Energy and Water Development Appropriation Bill, Congress directed the Department to acquire the former St. Louis, Missouri, Airport site and use it to dispose of waste from cleanup of the nearby Latty Avenue site and vicinity properties. Congressional and Departmental additions bring the total number of sites in the project to 25.

In FY 1985, the Department expects to complete cleanup work at the 23 contaminated properties near the DOE-owned Niagara Falls Storage Site in Lewiston, New York. Work will continue on the installation of an interim cap on the waste storage area and will be completed by December 1985. Other remedial actions at this site are described under the Surplus Facilities Management Program. The Department is also continuing the remedial actions at the Middlesex Landfill in New Jersey, to be completed by December 1985. This is about a year later than originally planned, due to a large increase in the estimated volume of contamination and the limitation on funds. The discovery that the volume of contaminated soil at the landfill is 5 times the amount originally estimated illustrates the difficulty of predicting the amount of contamination when it is deeply buried. Material contaminated with uranium and its decay products is being excavated from the landfill and stored temporarily at the nearby DOE-owned Middlesex Sampling Plant.

Decontamination actions begun in FY 1984 will be continued in FY 1985 at Maywood, New Jersey; Wayne/Pequannock, New Jersey; Colonie, New York; and Hazelwood, Missouri. The general approach to these projects is to give priority to the cleanup of contaminated residential properties and to store the waste temporarily on each processing site. The cleanup of residential properties associated with the Maywood site will be completed in FY 1985, and cleanup of commercial properties will be started. In FY 1986, cleanup of the Maywood commercial properties will be continued, with a goal of completion by the end of FY 1987. The waste from this site is being stored on the Stepan Company property at Maywood under a no-cost lease. The Department is reviewing options for stabilization-in-place of the more than 200,000 cubic yards of waste, or removal to a new disposal site in New Jersey.

At Wayne, New Jersey, the cleanup of a ballfield and a bus yard will be completed in FY 1985, as will the engineering of the cleanup of the adjacent Sheffield Brook site. In FY 1986, the cleanup of Sheffield Brook will be completed. W.R. Grace donated the Wayne site and $800,000 to DOE in September 1984. Modifications are being made to the site so that wastes can be stored on the site temporarily. The site is considered unsuitable for permanent stabilization. The State of New Jersey has been requested to nominate candidate locations in the State for DOE to establish a site for disposal of the estimated 50,000 cubic yards of waste at Wayne, as well as the other FUSRAP waste at Middlesex and Maywood.

At Colonie, New York, DOE acquired the NL Industries site as a donation in February 1984, along with two adjacent parcels owned by the Niagara Mohawk Power Company that have waste buried on them. In FY 1985, the shipment of hazardous chemical wastes from the former NL plant to an approved disposal site will be completed. Radiological surveys of a total of 56 properties will also be completed. Cleanup of 11 sites was completed by October 1984, an additional 25 properties will be cleaned up by October 1985, and the remainder will be completed by October 1986. The contaminated soil is being stored inside the plant. The Department is studying options for the stabilization-in-place or removal of the more than 30,000 cubic yards of waste to a new disposal site in New York. The State has been requested to nominate candidate locations for a DOE disposal site in New York.

At Hazelwood, Missouri, DOE has arranged with the site owner, Futura Chemicals Company, to use a part of the site for storage of contaminated soil. Cleanup of a portion of Latty Avenue, adjacent to the Hazelwood site, was initiated in FY 1984 and will be completed in FY 1985. Border areas on the site were cleaned up to prevent recontamination of Latty Avenue, and fencing was installed around the site. Radiological surveys of the vicinity properties will be completed in FY 1985. Cleanup activities will not be started until the waste can be moved to the St. Louis Airport storage site. Funds are included in the FY 1986 budget to prepare the engineering studies for this cleanup and transport. DOE has initiated discussions with the City of St. Louis, Missouri, for the acquisition of the former St. Louis Airport storage site for use in disposing of the estimated 60,000 cubic yards of waste from the Hazelwood site and vicinity properties, as required by language contained in the recent report that accompanied the FY 1985 Energy and Water Development Bill. If funds are available, the work at this site could start in FY 1987.

Work at other sites continued in FY 1984. Remedial action was completed at four laboratories at the University of Chicago. Preliminary engineering was completed for the radiological cleanup of the Middlesex Sampling Plant in New Jersey and the Bureau of Mines site at Albany, Oregon. A radiological survey report was prepared for the Dupont site in Deepwater, New Jersey. No further work will be done at these sites in FY 1985 and FY 1986, so that funds can be directed to work at the five highest priority sites.

A revision to the FUSRAP Project Plan is being prepared in FY 1985. A preliminary total cost estimate of $640 million has been made for the current scope of FUSRAP, based on completion of all the work by the year 2001.

Grand Junction Remedial Action Project

Under Title II of Public Law 92-314, Congress authorized financial assistance to the State of Colorado to limit radiation exposure resulting from the use of uranium mill tailings for construction purposes in Grand Junction, Colorado. This State and Federal cooperative effort is administered by the Colorado Department of Health through DOE's Grand Junction Area Office. The remedial action provides for removal of uranium mill tailings from the premises of an estimated 604 structures where concentrations of radioactive radon and its decay products exceed guidelines established by the Surgeon General. Public Law 95-236 extended the time, which has now expired, for property owners to apply for inclusion and also increased the authorized funding for the program. Federal funds cover 75 percent of the program costs, with the State providing the balance. Contingent upon the availability of adequate funding from the State of Colorado, the remedial action is expected to be completed in FY 1987, with final radiological verification to be completed in FY 1988.

At the end of FY 1984, work had been undertaken on 559 structures. In FY 1985, radiological assessments will be continued, and remedial actions will be initiated at 10 additional structures, including 8 residences and 2 schools. In FY 1986, work is scheduled to be undertaken on 7 properties, including 4 commercial structures, bringing the total number of properties completed to 576 out of the estimated total of 604.

Uranium Mill Tailings Remedial Action Project (UMTRAP)

UMTRAP is responsible for conducting remedial action at 24 former uranium ore processing sites and several thousand contaminated vicinity properties, as mandated by Public Law 95-604, the Uranium Mill Tailings Radiation Control Act of 1978. Nine of the sites are designated as high priority, six as medium priority, and nine as low priority. The Act requires completion of the program by March 1990 to standards promulgated by the Environmental Protection Agency. Project implementation is proceeding on this basis, and the funding level requested for FY 1986 is required to maintain this schedule.

The program strategy is to focus near-term program activities on the higher priority sites and on vicinity properties. Remedial actions are being conducted in accordance with cooperative agreements negotiated with the affected States and Indian tribes. Federal funds cover 90 percent of the remedial action costs (100 percent for the sites on Indian lands). The type of remedial action for the processing sites will be to stabilize the mill tailings in place, where possible, or to remove them to a new disposal site. In either case, the final disposal sites will be Federally owned and maintained under Nuclear Regulatory Commission (NRC) licenses. Engineering plans and environmental documents are prepared for the cleanup and disposal operations at each site. Concurrences by the Nuclear Regulatory Commission and the affected State or Indian tribe are required for the remedial action plan at each site. The project also involves the cleanup of contaminated vicinity properties. It is estimated that some 4,000 to 6,000 vicinity properties, mainly in the Grand Junction area but not covered by the Grand Junction Remedial Action project, may be found to be eligible for cleanup under this project. The Department's Albuquerque Operations Office has the lead role in implementing UMTRAP.

Specific actions underway in FY 1985 include the completion of remedial action at Canonsburg, Pennsylvania, and initiation of remedial action at Salt Lake City, Utah; and Shiprock, New Mexico. The implementation of the remedial action at the Salt Lake City processing site has been assigned to the State of Utah, at their request. The approach at this site is to relocate the tailings to a site near Clive, Utah. Cleanup will also continue at high-priority vicinity properties near the sites at Canonsburg, Pennsylvania; Salt Lake City, Utah; Grand Junction, Colorado; and Edgemont, South Dakota; and will be started at Shiprock, New Mexico; Riverton, Wyoming; and Durango, Colorado.

During FY 1986, work will be underway at seven processing sites. The work at Salt Lake City will be brought to an estimated 40 percent of completion, and the work at Shiprock will be completed. Onsite work will be started at the processing sites at Durango and Gunnison, Colorado; Tuba City, Arizona; and Lakeview, Oregon. Over 400 vicinity properties located at several high-priority sites will also be decontaminated.

Surplus Facilities Management Program

This program provides for the safe management and disposition of the inventory of surplus radioactively contaminated DOE-owned facilities from civilian nuclear energy development programs. The decontaminated facilities and sites are to be returned to other productive use, where appropriate. (All similar work for defense-related facilities is separately budgeted as Atomic Energy Defense Activities.) The civilian facilities are grouped into 34 projects under this activity. A long-range plan was completed in April 1985, establishing the schedule and priorities for sites currently in the surplus inventory. Priorities are established and work schedules are developed through analysis of legal, economic, and health and safety factors for each site. The Department's Richland Operations Office has the lead role in implementing this program.

In FY 1984, the major onsite cleanup and upgrading of storage facilities was continued at the Niagara Falls Storage Site in Lewiston, New York. About 93 percent of the 4,000 cubic yards of residue stored in a 160-foot tower were transferred through a 3/4-mile pipeline to a low concrete building at the waste storage area. This major task will be completed in June 1985. A thick clay cap is being placed over the wastes to prevent water infiltration and is designed to perform satisfactorily for a minimum of 25 years. Installation of the cap is scheduled for completion by December 1985. Alternatives for the long-term management of these wastes were examined in an Engineering Evaluation of Alternatives report and in a draft Environmental Impact Statement (EIS). A final EIS is to be issued in FY 1985. A geohydrologic report on the site was also issued. In FY 1986, surveillance and maintenance of the site is planned. Implementation of a long-term management option would be deferred to use available funds for higher priority work.

Work on the reconditioning of contaminated facilities at the Mound Laboratories in Miamisburg, Ohio, will be continued in FY 1985 and FY 1986, reaching an estimated completion of 72 percent and 83 percent, respectively. This 10-year project was begun in 1978.

Responsibility for the Shippingport Atomic Power Station was turned over to this program from the Naval Reactors program in September 1984, as planned. A site office for DOE and supporting United Nuclear Corporation staff was established to oversee Shippingport decommissioning activities. The General Electric Company began maintenance activities at the plant, and planning for procurement of decommissioning operations subcontractors is underway. Physical dismantling of portions of the plant will be started in September 1985 and is scheduled to be completed in FY 1990, about 1-1/2 years later than previously planned, due to the need to establish funding priorities within Departmental budget constraints.

In FY 1984, the Department continued to carry out necessary interim site maintenance and monitoring and continued to plan long-term remedial actions at the Weldon Spring, Missouri, site. A geologic report and an Engineering Alternatives Analysis report were issued. In FY 1985, planning and engineering will be continued. A radiological survey report for the surrounding area will be completed. Maintenance actions will be completed on the raffinate pit (storage pond) dikes. Preparation of a draft EIS to be issued in 1985 is underway. The Department's preferred alternative is stabilization of the wastes onsite in a disposal facility designed to meet Environmental Protection Agency requirements for the stabilization of uranium mill tailings. Under an agreement recently signed with the Department of the Army, DOE will assume responsibility for decommissioning the chemical plant portion of the Weldon Spring site and disposing of the resultant wastes. During FY 1986, the engineering for the remedial action at the quarry will be completed, with the objective of initiating quarry cleanup in FY 1987. The Weldon Spring site remedial action project will be a major DOE project, with an estimated cost of about $260 million (in 1986 dollars) and a duration of 9 to 10 years. The Army will provide 50 percent of the funds for the cleanup of the chemical plant portion of the site. The Department plans to acquire a prime contractor for this project by competitive procurement in FY 1986.

Other activities in FY 1986 will include continuation of site and facility disposition projects at Monticello, Utah; Santa

Susana, California; Argonne National Laboratory, Illinois; Oak Ridge National Laboratory, Tennessee; Idaho National Engineering Laboratory, Idaho; and the Center for Energy and Environmental Research (CEER) at Mayaguez, Puerto Rico. Decommissioning of the reactor facility at CEER will be completed in FY 1986. At Monticello, Utah, mill tailings will be removed from 15 residential properties, leaving only about 10 properties to be completed in FY 1987. Design engineering and environmental assessment will be completed at the mill site, to allow work on the site to start in FY 1987.

West Valley Demonstration Project

The objective of the West Valley Demonstration Project is to demonstrate the solidification process for disposal of high-level nuclear wastes under the provisions of Public Law 96-368, the West Valley Demonstration Project Act. An integrated production-scale development and demonstration project for treating high-level liquid nuclear wastes will be carried out at the Western New York Nuclear Service Center, near West Valley.

Major activities to be performed as part of this project include: (1) decontamination required to prepare existing facilities and equipment to accommodate the solidification project; (2) removal of wastes from underground storage tanks; (3) development, design, construction, and operation of systems and necessary supporting facilities for the solidification of the wastes; (4) acquisition of containers for the permanent disposal of the solidified waste; (5) temporary storage and transportation of the solidified waste to an appropriate Federal repository for permanent disposal; (6) decontamination and decommissioning of the waste tanks, facilities, hardware, and material used in carrying out the project; and (7) disposal of low-level and transuranic wastes produced from project activities.

The estimate of total project costs through the waste solidification stage, excluding final decontamination and decommissioning of the facility, remains at $472.8 million (escalated). It is expected that the overall schedule will remain unchanged, and that the total project cost estimate will be reduced. The results of the validation review, to be conducted in FY 1985, will be contained in an upcoming quarterly progress report to Congress on this project.

The major emphasis at West Valley in FY 1985 was to begin verification testing of the vitrification and supporting systems in the Component Test Stand, to accelerate the design and construction of the supernate treatment system (the supernate is the liquid above the sludge in the tank) for operation in FY 1986, to continue waste mobilization and removal testing in the one-sixth scale model waste tank, to continue upgrading the radioactive waste treatment systems, and to continue hot cell decontamination to obtain space for systems that support the waste solidification process.

The FY 1986 program will result in operation of the supernate treatment system, which will be used to remove a majority of the radioactive constituents. The supernate represents nearly 90 percent of the volume and 50 percent of the radioactivity of the stored liquid waste. The radioactivity removed will be stored and later blended with sludge and glass formers prior to being fed into the melter. Verification testing of the Component Test Stand and one-sixth scale model waste tank will be completed. Major design activities associated with the waste removal, size reduction/TRU decontamination, high-level waste storage, and radwaste treatment systems will be completed, and procurements will be initiated as resources and designs permit. Decontamination of critically needed hot cells and of the spent fuel Receiving and Storage Area will be continued to meet project needs. Solidification of the West Valley wastes is scheduled to begin in 1988, with completion scheduled for 1990.

URANIUM ENRICHMENT

Finally, I would like to discuss the Department's Uranium Enrichment program. I will focus primarily on the major elements of our production and business strategy, including our plans for advanced technology selection and deployment.

The Department's funding request for the Uranium Enrichment program in FY 1986 is approximately $1.6 billion in budget authority, which is fully offset by $1.6 billion in projected revenue. The funds requested are distributed among the major elements of the program as follows:

Program Element	FY 1986 ($ in Millions)
Uranium Enrichment Activities	
Power	$ 884.0
Enrichment Research and Development	150.0
Gas Centrifuge Enrichment Plant	340.0
All Other	238.7
Total Expenditures	1,612.7
Uranium Enrichment Revenues	- 1,612.7
Net Appropriation	$ 0

The FY 1986 Congressional budget for Uranium Enrichment was prepared in advance of a number of key program decisions to be made this month. While the budget details may require some revisions after the technology selection, production, and business strategy decisions have been made, we believe that the key program objectives can be satisfied within a net zero appropriation for FY 1986. We expect to present additional detail on our budget request in the near future.

I would like to provide an overview of the world uranium market, summarize our uranium enrichment operations and construction activity, and conclude with a detailed discussion of the advanced technology selection process, the DOE enrichment enterprise strategy, the results on customer conversion to the new Utility Services contracts, and the status of our efforts with the uranium mining and milling industry.

ENRICHED URANIUM MARKET

In prior years, in our testimony to this and other Committees, the Department has provided a description of the complex and interrelated problems that have impaired earlier attempts by DOE to serve as a reliable, competitive supplier of enriched uranium. Over the past several years, the DOE share of the world market for uranium enrichment has dropped significantly, from approximately 100 percent in 1974 to approximately 47 percent today. DOE's share of the non-U.S. market has declined from approximately 100 percent in 1974 to approximately 32 percent today. The success of our competitors in eroding our market share is depicted in Figures 1 and 2. A worldwide glut of enriched uranium, the emergence of a secondary market for enriched uranium at depressed prices, pricing by our competitors at discounts from DOE prices, and the drastic change in currency exchange rates (see Figure 3) adversely affected our ability to compete with other suppliers.

Figure 4 shows that DOE has gone from a position of being the lowest-price to being the highest-price supplier over the past 4 years. In 1983, DOE analyzed this situation and developed a modified strategy to improve our market position. The purpose of the revised strategy was to stabilize DOE's market share by providing for an orderly reduction of excess inventories of enriched uranium and to stem the tide of customers turning to lower-price suppliers for their enrichment services.

The overall objectives of the Department's enrichment strategy are 1) to be responsive to the needs of our customers;
2) to be a reliable long-term supplier at predictable prices;
3) to offer enriched uranium at the lowest reasonable price, based on sound business practices; and 4) to operate the enrichment complex in a businesslike manner without Federal subsidy. To achieve these objectives, a market-driven approach was taken in developing a revised program strategy and in the offering of the new Utility Services contract on January 18, 1984.

All key program decisions will be driven by the demands of the marketplace. The scope and pace of research and development activities and decisions to add new capacity will be based on reactions from the marketplace, including continued acceptance of the new contract and our recent incentive pricing offer, trends of price competition, and the actions of our competitors.

In the near term, the strategy includes a commitment to develop and deploy enrichment technology when economically feasible -- that is, when operating costs below those of the existing gaseous diffusion plants have been demonstrated. The funding level and the pace of these programs will be based on a businesslike approach that will be determined by market share, the availability of revenues, and the potential of advanced technology to lower costs.

The enrichment market is expected to remain extremely competitive throughout the next decade. Foreign suppliers of enriched uranium, such as Eurodif and URENCO, are aggressively competing for all uncommitted enrichment demand at prices significantly below DOE pricing levels. These suppliers are helped by the favorable currency exchange rates, the supply diversification strategies of many customers, and other factors.

ENRICHMENT OPERATIONS

We continued enrichment operations at our three gaseous diffusion plants (GDPs) in 1984 and made significant progress in enhancing the overall economy of their operation. By shifting production to the source of cheapest power, we were able to reduce the average cost of the energy used to produce each separative work unit (SWU) by more than 10 percent during FY 1984. Through dedicated work on the part of the operating contractors (Martin Marietta and Goodyear) and by the Department, we have been able to identify alternative operating modes for the GDPs that have further enhanced their operating efficiency.

By using off-peak power at the GDPs, we predict that further significant savings can be achieved. Off-peak power was utilized in the GDP at Portsmouth, Ohio, through much of 1984 and is being utilized at the two other GDPs in Paducah, Kentucky, and Oak Ridge, Tennessee, in 1985. All of these efforts were undertaken to assure that operating costs are reduced, that near-term prices decline as rapidly as possible, and that the GDPs are operated in the most cost-effective manner possible during the remainder of their useful life.

GAS CENTRIFUGE ENRICHMENT PLANT

Construction of the Gas Centrifuge Enrichment Plant (GCEP) project, utilizing Set III machines, was continued in 1984, although at a slower pace. Procurement of the initial increment of Set III machines from the three manufacturers is continuing. The project slowdown was effected to assure that our investment prior to a final technology selection will be minimized, and that the GCEP design can be thoroughly evaluated in the context of the Set V gas centrifuge technology. The reevaluation of the GCEP design was necessary to assure that, if the Advanced Gas Centrifuge (AGC) concept wins the technology selection, it can be incorporated into the enterprise in an economically optimum manner. A significant project accomplishment last year was the completion of the installation of the first cascade of Set III centrifuges in March 1984. Test operation of the first train of 720 centrifuges, on gas, is beginning this month, with the test product being handled through temporary facilities.

ADVANCED ENRICHMENT TECHNOLOGY SELECTION

This month, the Secretary of Energy will choose between the AGC and Atomic Vapor Laser Isotope Separation (AVLIS) technologies and determine which of the two will receive primary emphasis for further development and demonstration prior to potential future deployment. Since the technology selection will be made before either the AGC or AVLIS process has been demonstrated at production scale, there will be residual technical and economic issues involving both technologies that will require resolution through demonstration at near full-scale prior to deployment. However, the lack of full-scale production data will not preclude a near-term selection between the two options. The Federal Government has been supporting the AVLIS program for about 12 years and the centrifuge program for over 20 years. A substantial base of analytical data exists, and partial-scale enrichment demonstrations of both technologies have been completed prior to the selection.

The task of choosing between the two technologies has been one of getting the data bases for both technologies into a form that permits objective comparison. DOE set this evaluation and selection process in motion in late 1983. Following an initial planning phase and discussions among the program participants on how a valid technology review could be conducted, we announced our plan for the technology selection in the spring of 1984. Evaluation criteria were issued in draft form, and the Mitre Corporation was retained in April 1984 to assist in the analysis. An exchange of technical and economic data between the AGC and AVLIS technology advocates took place last May. In June 1984, former Secretary Hodel approved the charter and membership of a Process Evaluation Board, which has been responsible for conducting the evaluation and selection process.

The tasks assigned to the Process Evaluation Board can be summarized as follows:

- To assess the status of science and technology for the AGC and AVLIS uranium enrichment processes
- To evaluate the capital costs and overall economics of the AGC and AVLIS processes as compared with those of the gaseous diffusion enrichment process
- To assess the impacts and risks to the U.S. uranium enrichment enterprise of different technology deployment scenarios.

The membership of the Process Evaluation Board is shown in Figure 5. The schedule established by the Board is shown in Figure 6, and a summary of the key evaluation criteria is shown in Figure 7.

In the initial stage of the selection process, DOE defined the technical and economic data to be provided by both the AGC and AVLIS advocates. Both groups were required to define the reference concept that would serve as the basis for comparison. In July 1984, the Board established the final evaluation criteria and methodology, based on inputs from all the program participants. It was agreed that these could be expanded or refined as the technical and economic issues became better developed. Only two refinements have been made to the evaluation criteria:

- A requirement that the technology advocates specify the potential for introducing their technologies in a modular form, to better match the needs of the markteplace, and
- A requirement that the advocates submit their information on a cost center basis, to provide another method for comparing the relative economics of the two processes.

There have been no other modifications of the selection criteria to date, and the evaluation has proceeded on schedule.

The Process Evaluation Board has been assisted in its evaluation effort by a peer review process, in which each proponent's data are critiqued by the other in the presence of the Board. After each advocate has presented the best case for the technical and economic merits of the specific technology, the opposing technology review team has had an opportunity to review and critique it. These reviews have included meetings with responsible technology developers, independent analyses, reviews by consultants, and other appropriate review activities. The results of the critiques have been presented to the Process Evaluation Board both verbally and in writing. The Board recognizes the value of peer review, but it is not relying solely on this effort as a means to develop its recommendations. The Board has also conducted independent analyses, employing the technical expertise of various enrichment experts. An independent economics assessment team from Martin Marietta Energy Systems and the Mitre Corporation has provided support in the conduct of independent economic studies and special technical analyses of issues raised in the peer reviews. To conduct a valid business evaluation of the technologies, it is imperative that relative uncertainties in performance, cost, and scheduling be established. This uncertainty analysis is being developed by the Process Evaluation Board after consultation with the review teams, technology proponents, and Mitre representatives.

The number and detail of these contributions and the qualifications of the parties involved in each assure that the process is thorough. Four major peer review meetings, chaired by the Process Evaluation Board, were held in October 1984, December 1984, February 1985, and April 1985. The final analysis by the Board is now being concluded, following the receipt of final experimental data.

In its deliberations, the Board will use all the available information -- i.e., the results of the peer review meetings, the sensitivity analyses on various factors that can affect the cost of separative work, and the evaluations of the entire uranium enrichment enterprise -- in formulating its recommendations.

Finally, the Board has sought comments from other sources, including electric utilities, consultants, and interested members of the public. DOE conducted an open meeting on the evaluation process in Washington on April 22, 1985. The extensive reviews, with input from a broad cross-section of experts and open critiques of all the data presented, should assure a thorough and objective evaluation.

The review of advanced enrichment technologies is a critical element in DOE's overall strategy for the enrichment enterprise. Decisions on advanced technology must be made in the context of the overall needs of the enterprise, and these decisions will drive other elements in our long-range business and operating plans.

ENRICHMENT ENTERPRISE STRATEGY

To assure that the plans for operating existing enrichment facilities, conducting research and development, constructing new facilities, and marketing and sales are well integrated, DOE is currently preparing a comprehensive uranium enrichment enterprise strategy, scheduled to be issued later this month. The strategy will describe how the individual parts of the uranium enrichment program are interrelated. It will provide an historical perspective of the enterprise, describe the challenge in the current marketplace for uranium enrichment, define near- and long-term objectives for the enterprise, translate the objectives into specific goals, and discuss how a business plan based on the objectives will be implemented. The document will treat DOE's pricing strategy, alternative means of financing the program, and how alternative institutional arrangements might affect the enrichment enterprise. The strategy document will also contain a summary of the findings and conclusions of the Process Evaluation Board and how they will be incorporated into the enterprise strategy. Finally, it will discuss the Department's long-range operating plans, including an analysis of customer demand, production alternatives for meeting that demand, sensitivity analyses of the demand estimates, comparative economics of various production options, and a reference production strategy for the next 10 years. The enterprise strategy will serve as the master plan for future conduct of the enrichment enterprise.

UTILITY SERVICES CONTRACT

The Department's analysis of the world market for enriched uranium, the strength of our competition, excess inventories, and enrichment capacity has confirmed that staying on the course we were on in 1983 would have been fatal for the U.S. uranium enrichment business. To survive, we had to develop a strategy that was driven by and responsive to market conditions. The major elements of our revised strategy were the offering of a new Utility Services contract with better terms and conditions for our customers, improving relations with customers, operating the enterprise in a more cost-effective and businesslike manner, and allowing market conditions to drive our major decisions. We can compete vigorously by being fully competitive in terms of price, reliability, and responsiveness to customer needs. In developing our business strategy, we considered the situation confronting various elements of the U.S. nuclear industry and concluded that our new approach should have benefits for all, since increased purchases of domestic separative work units would provide greater opportunities for purchases of domestic uranium, conversion, and fuel fabrication services.

As a result of this approach, the Department offered important new features in negotiating new Utility Services contracts, including:

- A reduced price ($135 per SWU) for separative work, with a long-term price ceiling;
- A customer option to offset up to 30 percent of requirements with purchases from suppliers of their choice, or by drawing down their own inventories;
- Shorter leadtimes (180 days) to confirm delivery quantities;
- Flexibility to select a variable tails assay option (VTAO); and
- Flexibility to terminate contracts with no termination charges, provided that 10 years advance notice is given to the Department.

Prior to conversion to the new Utility Services contracts, DOE's enrichment customers had several different types of contracts, including 3-1/2 and 5 year requirements contracts, adjustable fixed commitment contracts, and long-term fixed commitment contracts. To facilitate the conversion of the unique features of each contract type to the Utility Service contract, and to recognize the special circumstances of individual utility customers, we entered into negotiations with utilities during the conversion period.

Overall, the new contract offers significant advantages to our existing customers and to prospective new customers. Customers with fixed commitment contracts had the opportunity to convert to a contract with substantially shorter fixed commitment periods, to gain partial relief from their existing contractual commitments for future-year deliveries, and to work off their existing inventories, thus reducing the secondary market for enriched uranium. Customers with requirements contracts will benefit from the lower price and from the ability to purchase a portion of their requirements from the domestic and foreign secondary markets at even lower prices. In addition, they will be able to select the variable tails assay option, which they currently cannot do.

Because the new contracts are based on individual customer needs rather than on fixed commitments, we will not continue to feed the secondary market. To the contrary, the ability to purchase up to 30 percent of requirements from the marketplace will work away excess inventories of enriched uranium, and it is expected that the secondary market of DOE-produced enriched uranium will be exhausted in 1987. Working off excess inventories of enriched uranium is crucial to stabilizing supply and demand. Stabilization will help both the uranium enrichment enterprise and the uranium mining and milling industry by making supply, demand, and price more predictable in the future.

The reaction to the new contract proposals by both foreign and domestic enrichment customers has been most encouraging. Representatives of the Edison Electric Institute, whose members include the vast majority of DOE's enrichment customers, testified before Congress last year concerning the Department's Utility Services contracts. They encouraged their members to give the new contracts serious consideration and indicated that the contracts appeared "beneficial to the domestic ratepayers, to the balance of trade for the Nation, to achieving an enrichment program that is responsive to the overall market needs, and to encourage the proper allocation of limited Federal resources."

Our customers were responsive to the Department's offer to enter into negotiations. In fact, over 90 percent of our sales base entered into new contracts. Supply and demand are being normalized and stabilized, and now both the utilities and the enrichment enterprise can begin to operate in a more businesslike, predictable manner.

The Utility Services enrichment contract provides the flexibility for customers to select a purchase commitment from DOE for any percentage between a minimum of 70 and a maximum of 100 percent of their total enrichment requirements for the first 5 years. Each year, customers exercise the option to select a new percentage within the 70 to 100 percent range for the coming 6th year. As a result, DOE's only assurance of a firm market in the future is the minimum 70 percent purchase obligation under Utility Services contracts. The average commitment by those utilities that elected to convert to a Utility Services contract in October 1984 was about 75 percent of their total SWU requirements. In April 1985, taking advantage of the very low marginal costs of production from excess capacity, DOE gave those customers who had negotiated conversions to Utility Services contracts an opportunity to increase their purchase commitments with an "incentive price" offer of $90 per SWU for their uncommitted demand in the FY 1987 through FY 1990 time period. This offer was accepted by a substantial number of customers, resulting in an average additional purchase commitment of approximately 15 percent through FY 1990. Figures 8 through 10 are market share projections based upon firm commitments to DOE from conversions to Utility Services contracts and from the incentive price action and firm obligations to foreign suppliers. The future market share for DOE is estimated to be 49 percent of the world market and approximately 28 percent of the foreign market in FY 1990. Also, at the present time, about 41 percent of the world market and 25 percent of the foreign market are firmly committed to DOE in FY 1995. With the successful implementation of actions to make DOE's price more competitive, the market share in FY 1995 should improve.

URANIUM MINING AND MILLING INDUSTRY

Opportunities for additional sales by the domestic uranium mining and milling industry should also be enhanced by the new Utility Services contracts, which provide flexibility to our customers by offering a variable tails assay option. This feature allows the utilities to choose the tails assay that best suits their particular needs or circumstances, and thus permits them to optimize their costs for enriched uranium. Duke Power -- a major utility with five operating nuclear plants, one in power ascension, and one under construction -- has advised us that the net effect of its new contract has been an increase in required deliveries of uranium over the next 5 years. Another advantage to uranium suppliers results from the 70 percent/30 percent structure of the new contracts, which provides for a minimum commitment of 70 percent of the user's requirements to DOE. The utilities can satisfy the remaining 30 percent balance of their needs by working off their surplus inventories or by purchasing additional quantities from suppliers of their choice.

The sooner the utilities are able to work off their inventories, the sooner they will contract for additional supplies of uranium. For both the uranium industry and the enrichment enterprise, the next few years will be characterized by lower sales, as the inventories held by customers are worked off. This is not a result of the Utility Services contracts but rather an effect of the natural forces of the marketplace. In the past, feed and enrichment sales declined when customers with requirements contracts cancelled and delayed their deliveries with DOE, purchasing discounted enriched uranium from customers with fixed commitment contracts who were receiving deliveries that exceeded their consumption. Inventories were being worked off by random spot-market sales of enriched and natural uranium among utilities, and those sales were accompanied by terminations of contracts for future deliveries.

If no action had been taken, enrichment sales in the late 1980's would have dropped precipitously, to levels as low as 50 percent of 1983 deliveries. Thus, the problem of excess inventories was a real one. Had the Department not offered contract terms that would allow an orderly workoff of inventories, customers would have done so, but in a random, unpredictable way. One certainty was that reduced sales were inevitable over the next 5 years. For the future, we are also considering alternative approaches that will make us more competitive in terms of capturing the uncommitted 30 percent of customer needs not committed to DOE under the terms of the Utility Services contract. In April 1985, the Department sent to all Utility Services contract holders an "incentive price" offer, which included a no-cost variable tails assay option for commitments over 70 percent. As a result of this action, we captured an additional 15 percent of the uncommitted market covered by the Utility Services contacts. To the extent that most customers prefer to deal with only one country for their fuel services -- both natural uranium and enrichment work -- the enrichment sales that are denied to foreign competitors will also deny them a firm lock on any portion of the uncommitted demand. This means that if domestic SWU's are purchased, the domestic uranium industry will have a greater opportunity to supply the required feed material, whereas purchases of foreign SWU's increase the probability that the uranium feed will also be purchased from foreign suppliers.

In summary, we considered the U.S. uranium supply industry in negotiating and entering into Utility Services contracts, and we are aware that the enrichment enterprise shares the industry's problems of excess capacity, reduced demand, and severe foreign competition. We will continue to work closely with the domestic uranium mining and milling industry. We believe that our strategy will lay the groundwork for a financially sound uranium enrichment enterprise and, by doing so, may help to benefit the domestic uranium industry.

This concludes my statement, Mr. Chairman. I am accompanied today by Dr. Lyle C. Wilcox, who directs our reactor development programs, Mr. John E. Baublitz, who directs our remedial action programs, and Mr. John R. Longenecker, who directs our uranium enrichment enterprise. We will be pleased to answer any questions at this time.

FIGURE 1

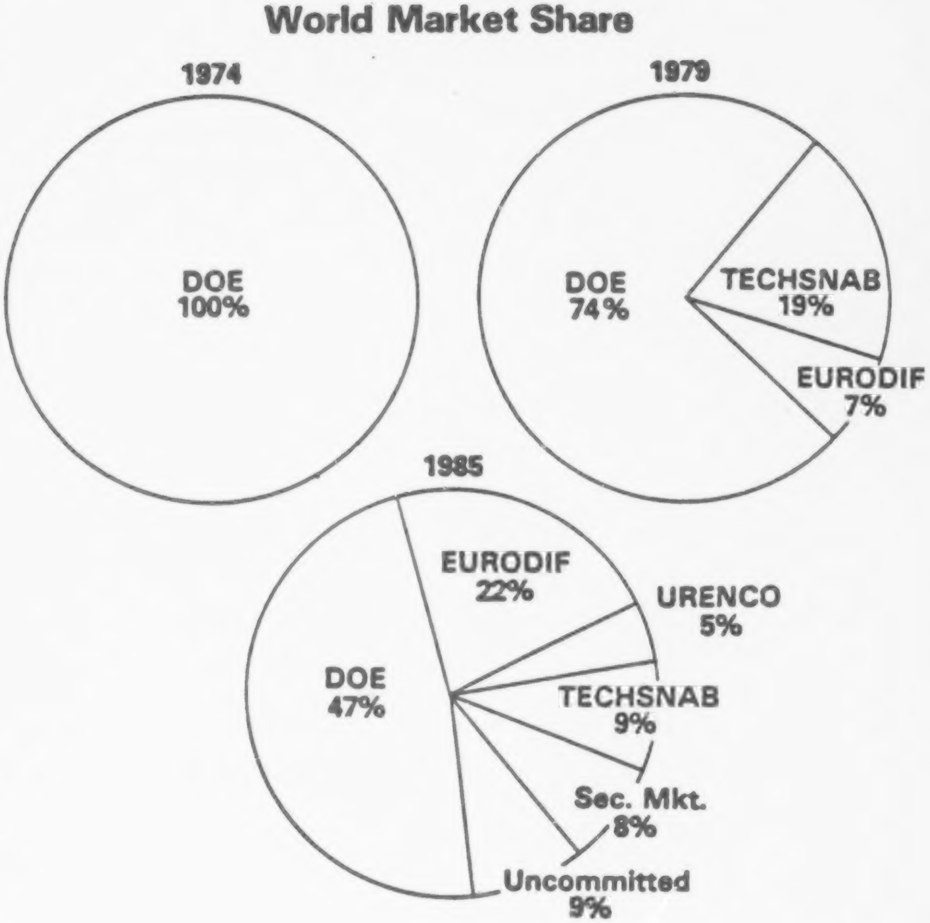

World Market Share
1974
DOE
100%
1979
DOE
74%
TECHSNAB
19%
EURODIF
7%
1985
DOE
47%
EURODIF
22%
URENCO
5%
TECHSNAB
9%
Sec. Mkt.
8%
Uncommitted
9%

FIGURE 2

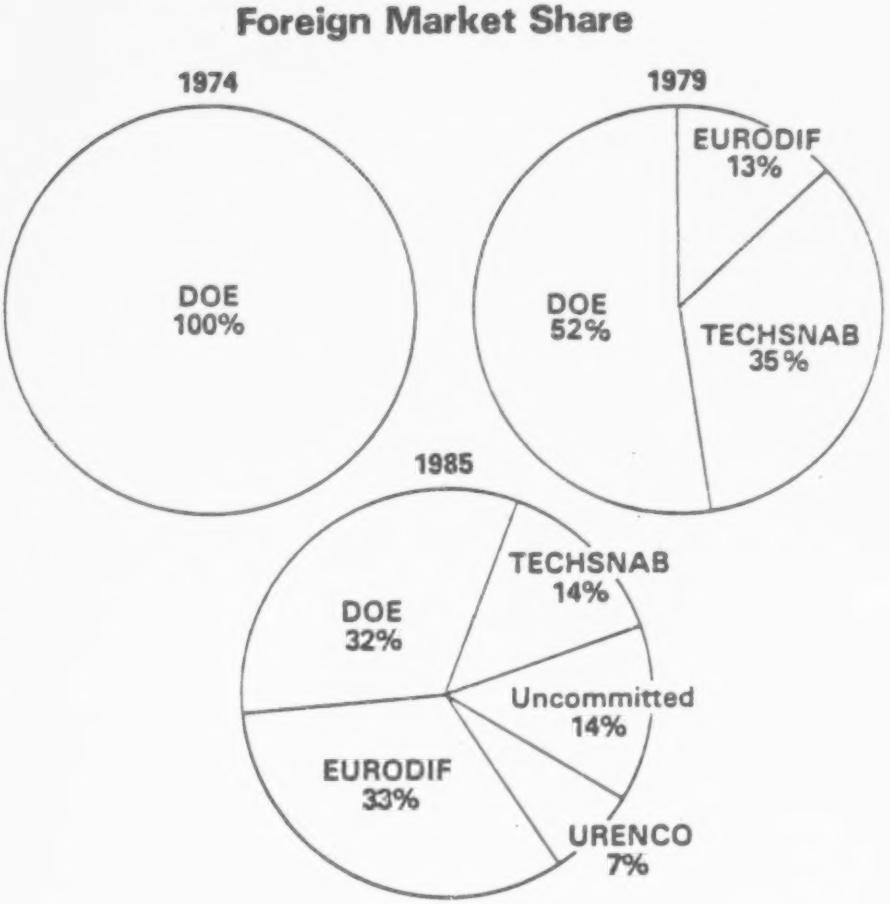

Foreign Market Share
1974
DOE
100%
1979
EURODIF
13%
DOE
52%
TECHSNAB
35%
1985
DOE
32%
TECHSNAB
14%
Uncommitted
14%
EURODIF
33%
URENCO
7%

FIGURE 3

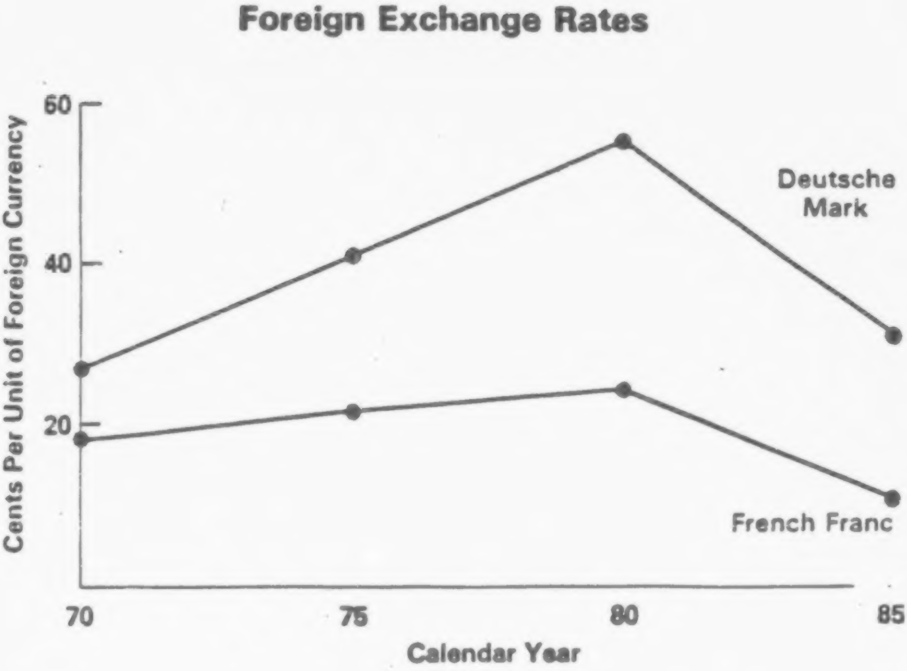

Foreign Exchange Rates
Cents Per Unit of Foreign Currency
60
40
20
Deutsche Mark
French Franc
70
75
80
85
Calendar Year

FIGURE 4

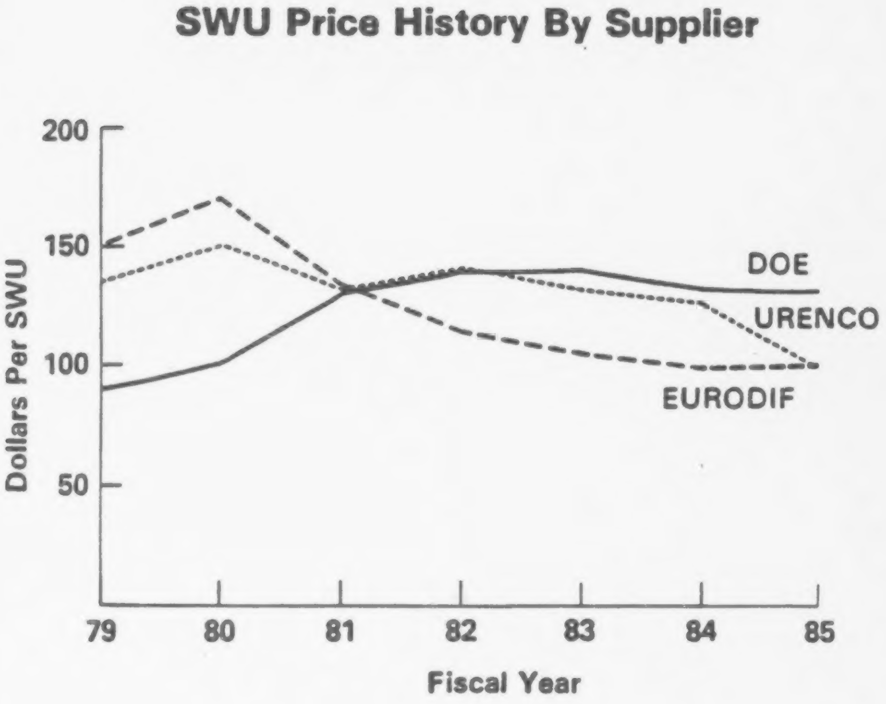

SWU Price History By Supplier
Dollars Per SWU
200
150
100
50
79
80
81
82
83
84
85
Fiscal Year
DOE
URENCO
EURODIF

FIGURE 5

Membership of Process Evaluation Board (PEB)

Member	Affiliation	Principal Review Responsibilities
● Peter T. Johnson Chairman	Administrator, Bonneville Power Administration	Business Management, Manufacturing & Market Analysis
● James E. Leiss Vice Chairman	Associate Director for High Energy & Nuclear Physics; Office of Energy Research	Science & Technology Management
● Kermit O. Laughon Exec. Secretary	Director, Office of Spent Fuel Management & Reprocessing Systems; Office of Nuclear Energy	Nuclear Engineering & Program Management
● C.N. Mitchell	Director, Office of Project & Facilities Management; Office of Management & Administration	Plant Design & Cost
● Norton Haberman	Director, Office of Advanced Technology; Office of Uranium Enrichment	Science & Technology
● Sherry E. Peske	Director, Office of Marketing & Business Operations; Office of Uranium Enrichment	Business, Economic & Market Analysis
● Joseph W. Parks	Assistant Director for Planning; Oak Ridge Operations Office	Program Planning, Business & Economic Analysis

FIGURE 6

Process Selection Schedule

● Interim Selection Criteria	Apr 17, 1984
● Establish Methodology For Comparison	Jul 31, 1984
● 1st Major Review Meeting	Oct 1984
● 2nd Major Review Meeting	Dec 1984
● 3rd Major Review Meeting	Feb 1985
● Experimental Data Cutoff	Apr 1985
● 4th Major Review Meeting	Apr 1985
● Complete Evaluation & Prepare PEB Report	May 1985

FIGURE 7

Selection Criteria For Enrichment Technologies

- **Major Figures of Merit**
    1. SWU Price
    2. Return on Investment
    3. Total Enterprise Cost
- **Major Consideration In Figures of Merit**
    1. Technical Feasibility of Each Concept
    2. Validity of Capital Costs To Construct Facility
    3. Validity of Operating & Maintenance Costs
    4. Future Potential For Privatization of Concept
    5. Ability To Deploy Concept Commercially in the Time Frame in Which U.S. Needs Cost-Competitive, New Capacity
    6. Ability to Maintain Viable Program Within Existing Budget Constraints
    7. Relative Risk of Each Process In Meeting Cost Goals
    8. Demand For Enriched Uranium

FIGURE 8

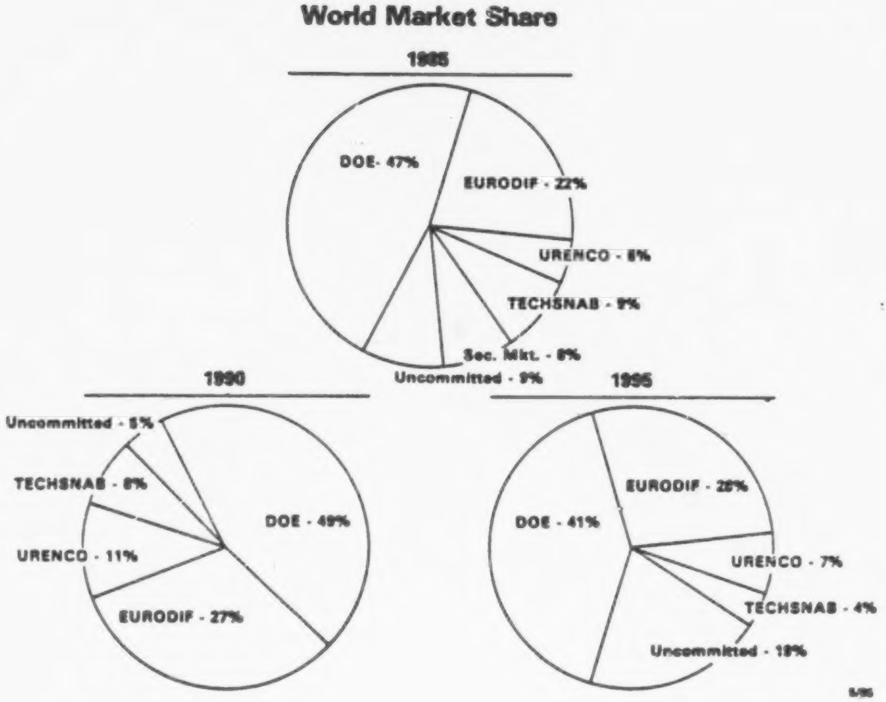

World Market Share
1985
DOE- 47%
EURODIF - 22%
URENCO - 5%
TECHSNAB - 9%
Sec. Mkt. - 8%
Uncommitted - 9%
1990
Uncommitted - 5%
TECHSNAB - 8%
URENCO - 11%
EURODIF - 27%
DOE - 49%
1995
EURODIF - 28%
DOE - 41%
URENCO - 7%
TECHSNAB - 4%
Uncommitted - 19%

FIGURE 9

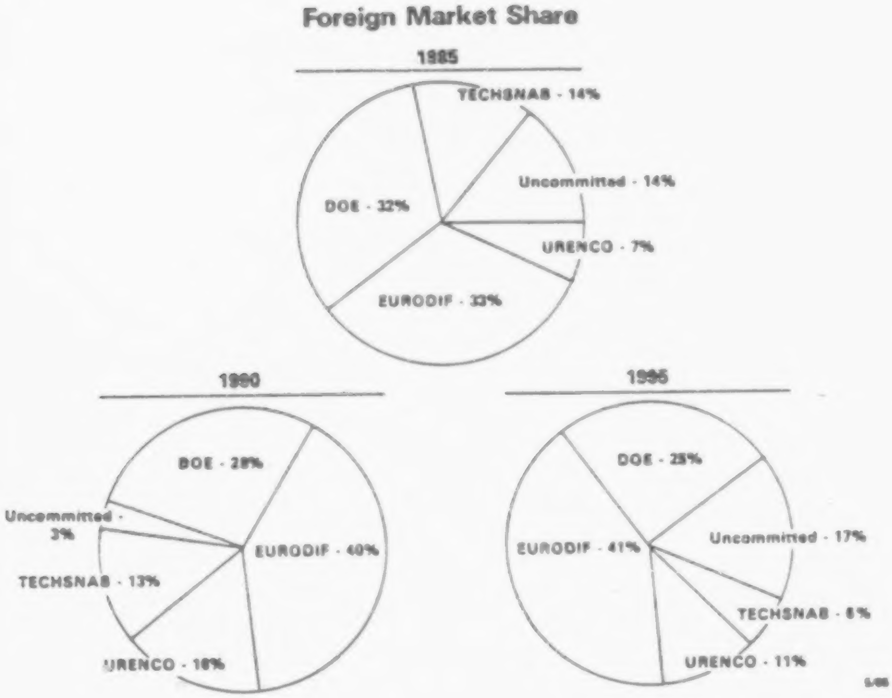
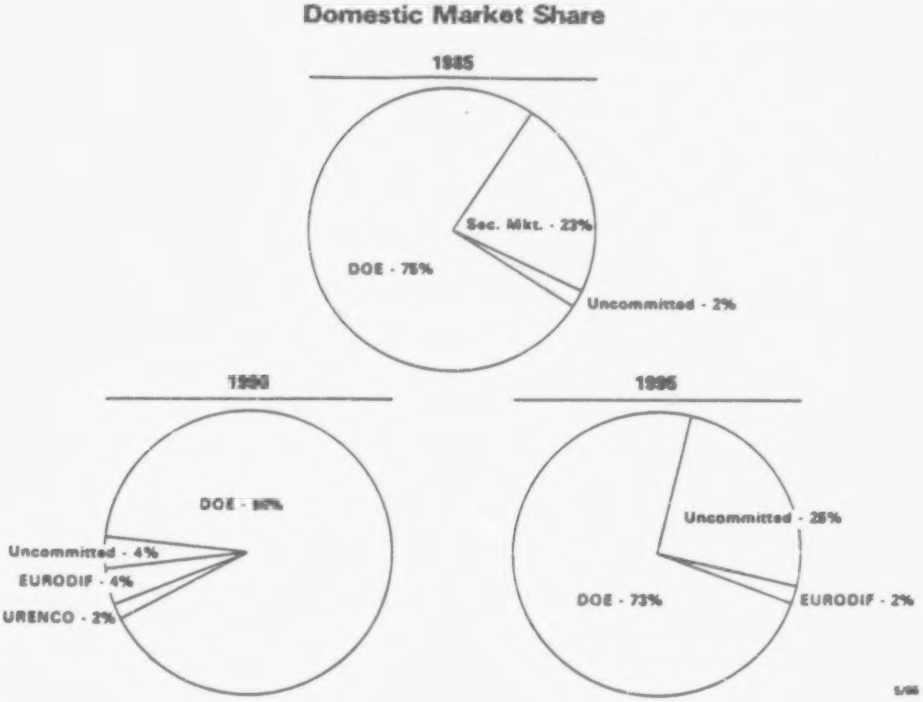

Foreign Market Share
1985
TECHSNAB - 14%
Uncommitted - 14%
DOE - 32%
URENCO - 7%
EURODIF - 33%
1990
DOE - 28%
Uncommitted - 3%
EURODIF - 40%
TECHSNAB - 13%
URENCO - 16%
1995
DOE - 25%
EURODIF - 41%
Uncommitted - 17%
TECHSNAB - 6%
URENCO - 11%
5/86

FIGURE 10


Domestic Market Share
1985
Sec. Mkt. - 23%
DOE - 75%
Uncommitted - 2%
1990
DOE - 90%
Uncommitted - 4%
EURODIF - 4%
URENCO - 2%
1995
Uncommitted - 25%
DOE - 73%
EURODIF - 2%
5/86

Mr. **Vaughan**. I do have with me today at the table to my left, Dr. Lyle Wilcox, who directs our breeder reactor programs; and to my far left, Mr. John Baublitz, who directs our remedial action projects; and to my right, Mr. John Longenecker, who directs our uranium enrichment activities.

We would be pleased to answer any questions you have for us at this time.

Senator **Domenici**. Before we proceed with the questions, let me ask is Mr. Rusche going to testify separately?

Mr. **Rusche**. [Nods in the affirmative.]

Senator **Domenici**. I wonder if the Senators would prefer that we have Mr. Rusche testify and then we can inquire of the entire panel.

Mr. **Vaughan**. Either arrangement is quite all right with us.

Senator **Domenici**. Why don't you proceed, Mr. Rusche?

STATEMENT OF BEN C. RUSCHE, DIRECTOR, OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT, DEPARTMENT OF ENERGY

Mr. **Rusche**. Thank you, Mr. Chairman, members of the Committee. I'm pleased to have the opportunity to speak to you this afternoon concerning the budget for the Civilian Radioactive Waste Management Program.

The fiscal year 1986 budget represents the second budget formulated by the Office of Civilian Radioactive Waste Management since passage of the Nuclear Waste Policy Act of 1982 and presents an integrated picture of programmatic activities for a total waste management system.

This year is my first opportunity to present a budget to Congress and today is my first opportunity to appear before this committee. And I'm grateful for that opportunity.

The act mandates a comprehensive set of Federal activities directed by DOE and designed to begin operating a Federal waste management and disposal system capable of accepting spent nuclear fuel and high-level radioactive waste for permanent disposal in 1998. DOE's commitment to begin operating this system and receiving spent fuel in 1998 is unequivocal.

In the integrated system that we propose, monitored retrievable storage, which the act requires us to consider, and transportation are major subsystems along with repositories.

The act established the nuclear waste fund financed by fees collected from owners and generators of spent fuel and high-level waste as a funding source for the Nuclear Waste Program. For this businesslike environment, the Department intends to conduct the program within the revenue.

The fiscal year 1986 budget request for the nuclear waste fund is $571.5 million, which is up from $327.7 million in fiscal year 1985. And I will speak to that increase in just a moment.

The NWPA requires DOE to submit a triennial budget for the nuclear waste fund. The estimates, including discussion of specific activities planned for the outyears, are in the total waste fund budget submission, and I trust that that whole submission will be included in the record, Mr. Chairman.

Senator **Domenici**. It will be.

Mr. Rusche. The estimate for fiscal year 1987 is $836.1 million and, for fiscal year 1988, it's $685.5 million. Of the $571.5 million requested for 1986, $486.7 million is for first repository activities. This is for extensive site characterization drilling and testing, exploratory shaft construction and intensive engineering tests, analyses of waste package designs, and analyses of repository designs. The fiscal year 1985 budget is $235.5 million, excluding the $8.9 million that was reprogrammed to MRS with your committee's approval just recently.

Under our current schedule, DOE plans to formally recommend to the President this fall three sites for detailed site characterization. We issued draft environmental assessments last December which indicated our proposal to recommend Yucca Mountain in Nevada, Deaf Smith in Texas, and Hanford in Washington for this site characterization. We are currently reviewing over 17,000 comments on the draft assessments.

Our current plans are to recommend to the President in the 1990–91 timeframe one site for the first repository and we hope to have the final environmental assessments out and our recommendations to the President by the end of this year.

You will recall from the act that it is only the first repository that is currently authorized. The act calls for us to proceed with planning activities for a second repository, but does not authorize construction of it.

The activities required to give Congress and the President a basis for considering the second repository are aimed at a Presidential site recommendation in 1997. The fiscal year 1986 budget request for the second repository is $43.9 million compared to $24.7 million for 1985.

The fiscal year 1986 budget request for MRS is $12.9 million. This request assumes for planning purposes that Congress will authorize DOE to proceed with activities that are critical for deployment of an integrated MRS facility capable of meeting waste system needs and providing assurance of our ability to accept waste beginning in 1998.

On April 25, we identified three candidate sites to be included in the site-specific proposal which we are required to submit to the Congress for consideration. All three candidate sites are in Tennessee, and the preferred one is the former Clinch River Breeder Reactor site. The other two alternative candidate sites are the DOE Oak Ridge Reservation and the former Tennessee Valley Authority reactor site at Hartsville, TN.

Congress has not authorized construction of an MRS facility but has directed DOE to evaluate MRS and prepare a proposal. We will report to the Congress next month our preliminary conclusions to date and will indicate our intent to provide in January of 1986 a complete proposal to Congress.

We believe an MRS facility should be an integral part of the waste management system and we consider it an essential element in achieving overall system objectives. To support this position, we requested authority from Congress to reprogram $8.9 for 1985 to allow the design and siting work necessary to present a plan for congressional approval that reflects this concept. This request was recently approved. The fiscal year 1985 budget level for MRS is, therefore, $17.5 million.

While our 1986 budget request assumes, as I mentioned a moment ago, that Congress will authorize us to proceed with development of MRS, I need to point out very specifically that we fully understand the limits of authorization that are upon us and we will not proceed with detailed activitiesl unless and until the Congress acts on that proposal.

Transportation is probably the part of our activities which affects the lives of more Americans than any other part of our program. I believe that we will undoubtedly receive a great deal of public attention in this area over the next several years. Our budget request in this area, therefore, represents the greatest increase over fiscal year 1985 than any other activity.

The request for transportation and systems integration is $22.6 million and is intended to accelerate development of adequate transportation and integrated systems for shipping and management of nuclear waste among the various components of the disposal system. This compares with $2.4 million in 1985.

Beyond the nuclear waste fund, for generic research and development activities, $23.4 million is requested for appropriation from the general fund. The fiscal year 1985 budget level is $26.4 million.

The act does not permit generic research under the nuclear waste fund as we read it. The work under this generic research request is aimed at three specific areas: cask and storage system development; international programs to promote cooperation; and alternative disposal methods. The only alternative disposal method or concept which we are currently studying in detail is disposal in the deep subseabed and this is part of a well-coordinated international effort.

Mr. Chairman, this concludes my brief overview of our 1986 budget request. I'd be happy then to respond to questions whenever you think it appropriate, sir.

[The prepared statement of Mr. Rusche follows:]

STATEMENT BY

BEN C. RUSCHE
DIRECTOR
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
U.S. DEPARTMENT OF ENERGY

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
UNITED STATES SENATE

MAY 13, 1985

Mr. Chairman and Members of the Subcommittee:

I am pleased to appear before you today to discuss the Department of Energy's (DOE's) Fiscal Year 1986 Civilian Radioactive Waste Management budget and programs. The FY 1986 budget represents the second budget formulated by the Office of Civilian Radioactive Waste Management since passage of the Nuclear Waste Policy Act of 1982 and presents an integrated picture of programmatic activities for a total waste management system.

The Nuclear Waste Policy Act of 1982 mandates a comprehensive set of Federal activities directed by DOE and designed to begin operating a Federal waste management and disposal system capable of accepting spent nuclear fuel and high-level radioactive waste for permanent disposal by 1998. DOE's commitment to begin operating this system and receiving spent fuel by 1998 is unequivocal. In carrying out the requirements of the Act, this will provide a permanent solution to this important national problem and will allow utilities and their ratepayers assurance in planning for such disposal.

The Act confirms DOE's earlier decision that deep, geologic repositories, can safely and permanently isolate high-level waste from the public and the environment. It is clear, however, that within an overall waste management system, transportation, handling, packaging, storage and disposal are integral parts.

In the overall system, a Monitored Retrievable Storage (MRS) option, which the Act requires us to consider, and transportation are major subsystems along with geologic repositories. The importance of integration of these systems is reflected in the FY 1986 budget request which includes, for the first time, a separate budget line item for transportation and system integration.

The Nuclear Waste Policy Act created the Nuclear Waste Fund which is financed by fees collected from owners and generators of spent fuel and high-level waste. The Nuclear Waste Fund creates the necessity for managing the program like a business. The requirements, as well as the opportunity, for fiduciary responsibility and accountability are almost unprecedented in the Federal Government for such a major development and construction program. And I am committed to conducting the program within our revenue.

Research and development activities not financed under the Nuclear Waste Fund, such as, research and cooperative agreements on spent fuel and research on alternative disposal concepts, are funded under the Energy Supply Research and Development Appropriation in a program entitled Civilian Radioactive Waste Research and Development (R&D).

The FY 1986 budget request for budget authority funded by the Nuclear Waste Fund is $571.460 million.1/ This budget request is summarized in Table 1. The FY 1986 Departmental budget request for Civilian Radioactive Waste R&D is $23.4 million. This budget is summarized in Table 2.

1/ The Nuclear Waste Policy Act requires the Secretary to submit a triennial budget for the Nuclear Waste Fund. The discussion of specific activities presented in the Nuclear Waste Fund Program gives estimates for FY 1987 and FY 1988. The estimates for the total Waste Fund Program are: FY 1987 - $836.1 million; FY 1988 - $685.5 million.

TABLE 1

FY 1986 CONGRESSIONAL BUDGET
NUCLEAR WASTE FUND
(Budget Authority in Thousands)

	FY 1984 Approp.	FY 1985 Approp.	FY 1986 Request
NUCLEAR WASTE FUND			
Repository Deployment			
o First Repository	$246,560	$235,400b/	$436,800
o Second Repository	16,270	24,700	43,900
Monitored Retrievable Storage	12,000	17,500b/	12,900
Transportation and Systems Integration	3,900	2,400	22,625
Program Management and Technical Support	36,191	44,369	55,235
Debt Service (Interest)a/	4,700	3,300	----
TOTAL	319,621	327,669	571,460
Projected Receipts			
o One mill/KWh fee	329,539	350,300	401,100
o One-time Fee	----	770,000	----
TOTAL	329,539	1,120,300	401,100
Interest Income	----	21,798	86,640
Staffing Full-Time Equivalents (FTE's)	172	266	292

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a/ DOE anticipates collection of approximately $770,000,000 from utilities who plan to exercise the lump sum option for spent fuel discharged prior to April 7, 1983. After receipt, DOE will repay the appropriated debt of $258,443,270.

b/ Funding levels reflect reprogramming action approved by the Congress in April 1985 to complete MRS proposal to Congress.

TABLE 2

FY 1986 CONGRESSIONAL BUDGET
ENERGY SUPPLY RESEARCH AND DEVELOPMENT ACTIVITIES
(Budget Authority In Thousands)

	FY 1984 Approp.	FY 1985 Approp.	FY 1986 Request
CIVILIAN RADIOACTIVE WASTE R&D			
Spent Fuel Storage Development	$ 5,000	$12,625	$ 8,900
Alternative Disposal Concepts	7,500	11,475	12,500
Generic Methods and Supporting Studies	1,550	2,021	1,650
Program Direction	130	266	325
TOTAL	14,180	26,387a/	23,375
Staffing FTE's	2	5	5

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a/ Reflects reductions as follows: General Reduction, $660,000; ADP Reduction, $550,000; and Rescission, $43,000.

Before discussing the details of the FY 1986 budget request, I would like to discuss briefly the strategy of the program and summarize major accomplishments since enactment of the Nuclear Waste Policy Act as well as the status of the program.

PROGRAM STRATEGY

The major goal upon which the program strategy is based is that spent nuclear fuel and high-level nuclear waste must be disposed of in a manner that adequately protects public health and safety and the environment for this and future generations. To do so, a comprehensive waste management system must be implemented.

The Nuclear Waste Policy Act of 1982 established the method of disposal, a schedule, technical processes, institutional processes and a funding mechanism to ensure successful implementation of the Act.

There are numerous intermediate dates and key milestones laid out in the Act of which I am aware the Subcommittee and others have voiced concern. Some observers may, in fact, look at our efforts to date and conclude that we have slipped schedules to the extent that the 1998 commitment may not be met. On the other hand, some believe we are driven only by milestones engraved in the Act, and that we are not committed to full and open participation by affected and interested parties as called for in the Act.

As I stated earlier, our commitment to begin receiving spent fuel in 1998 is unequivocal. In meeting that commitment, I wish to emphasize that we are committed to "success" -- not just "timely success."

Our success in meeting the milestones on the schedule laid out in the Act has not been as high as some would like. But we recognize that our best chance for accomplishing the mandate of the Act is to do well what is required. For this reason, some of the milestones in the early decisional stages are indeed far more important than later ones and, therefore, worth investing adequate time and resources to assure a quality result. The interests of States, Indian tribes and other affected and interested parties must be considered fully.

So while we have taken more time to accomplish many of the early milestones called for by the Act, we believe that the quality of the results to date indicates now and will prove later to be an appropriate expenditure of time.

Keeping the importance of the interactive process in mind, our program strategy is to optimize the total waste system to the extent practical in terms of safety, environmental protection, cost-effectiveness and schedule, taking into account transportation, packaging, storage, system reliability, overall costs and the logistics and associated interface problems.

The overall strategy of the program, therefore, is to:

o carry out a comprehensive set of Federal and Federal-State interactive activities to site, design, construct and operate the Nation's first permanent nuclear waste repository;

o proceed with activities for proposing deployment of an MRS facility as an intermediate packaging and handling facility;

o develop a transportation system to assure that a safe, environmentally acceptable and cost-effective transportation system is in place by 1998;

o support those subsystems -- such as, licensed cost-effective technologies for at-reactor storage -- necessary for development of the total waste management system; and,

o ensure fiduciary responsibility in the execution and management of technically sound, cost-effective programs.

MAJOR ACCOMPLISHMENTS AND STATUS OF PROGRAM

POTENTIALLY ACCEPTABLE SITES

When the Act became law in January 1983, DOE had under study nine sites for consideration for the first repository. These sites emerged from extensive technical, socioeconomic, environmental and institutional analyses that had been undertaken by DOE during the past decade. In February 1983, those sites, including two in Utah, one in Washington, one in Nevada, two in Texas, two in Mississippi and one in Louisiana, were formally identified as being potentially acceptable sites for the first repository and notifications were made to the Governors of those States, the State legislatures and the tribal councils of affected Indian tribes of the potentially acceptable sites within these States.

NUCLEAR WASTE FUND

In April 1983, DOE adopted a fee of one mill (one-tenth of a cent) per kilowatt hour charged to utilities for all nuclear-generated electricity beginning April 7, 1983, as specified in the Act. Revenues collected by DOE through February 1, 1985, total approximately $553.6 million.

In addition to spent fuel generated since April 7, 1983, spent fuel or high-level waste generated prior to that date is subject to a fee equivalent to an average charge of one mill per kilowatt hour. Utilities have until June 1985 to decide on one of three payment options. The estimated revenue from the one-time fee for this spent fuel is approximately $2.3 billion. While it is not possible to know for certain when these revenues will be available to the Fund, DOE undertook three separate surveys to determine utilities' intent in paying this one-time fee. About 50 percent responded that they would pay approximately $770 million by June 1985 in order to save interest charges which would accrue under the payment options.

DOE has issued three annual fee adequacy evaluation reports, the latest of which was submitted to Congress in mid-February. The latest report -- Nuclear Waste Fund Fee Adequacy: An Assessment -- indicates that no adjustment of the one-mill per kilowatt fee is necessary at this time.

DISPOSAL CONTRACTS

By June 1983, disposal contracts were signed with all then existing owners and generators of spent fuel and high-level waste. Since then, additional contracts have been signed covering new nuclear power plants which have come on line. As part of the contract, DOE is currently developing a waste acceptance schedule.

ANNUAL REPORT TO CONGRESS

In February 1984, DOE issued the first Annual Report to Congress. The second Annual Report is in the final stages of preparation.

MISSION PLAN

In May 1984, DOE issued a draft Mission Plan for public review and comment. The purpose of the Mission Plan, as prescribed in the Act, is to provide an information base sufficient to permit informed decisions to be made in carrying out the repository and other programs mandated by the Act. An updated Mission Plan is currently in preparation and we expect to submit it to Congress the end of May 1985.

REPOSITORY SITING GUIDELINES

On December 6, 1984, and after extensive review and comment by interested States, affected Indian tribes, Federal Agencies and the public, and after concurrence by the Nuclear Regulatory Commission, DOE issued General Guidelines for the Recommendation of Sites for the Nuclear Waste Repositories.

REPOSITORY DEVELOPMENT

On December 20, 1984, DOE issued for ninety days public review and comment draft Environmental Assessments proposing five sites for nomination as suitable for site characterization for the first repository and proposing three of those sites as preferred for recommendation to the President for site characterization. The five sites proposed for nomination for site characterization are, in alphabetical order by State:

- Richton Dome in Mississippi;
- Yucca Mountain in Nevada;
- Deaf Smith in Texas;
- Davis Canyon in Utah; and,
- Hanford in Washington.

The three sites proposed for recommendation for site characterization are:

- Yucca Mountain,
- Deaf Smith, and
- Hanford.

During the 90-day comment period, DOE held some 50 briefings in the affected States to facilitate the review of the documents and conducted 19 public hearings to receive testimony on the documents.

After consideration of oral and written comments, and consultation with affected States and Indian tribes, DOE will prepare final Environmental Assessments. The Secretary of Energy will formally nominate at least five sites as suitable for site characterization and each nomination will be accompanied by a final Environmental Assessment. He will then recommend three of the nominated sites to the President for site characterization as candidate sites for the first repository. Site characterization will occur only at the sites recommended to and approved by the President. This recommendation is expected to occur in fall 1985.

After the three sites have been approved by the President, site characterization is expected to begin in FY 1986. This will involve an intensive site evaluation program including in situ testing at the bottom of deep exploratory shafts. Shaft construction at the three sites will take approximately two years with in situ tests planned for FY 1988 through FY 1990. Currently, DOE plans to construct two shafts at each site.

Before proceeding to sink the exploratory shafts, DOE will submit to the Nuclear Regulatory Commission and to the States and affected Indian tribes of the recommended sites a site characterization plan for their review and comment. DOE will hold a public hearing in the vicinity of each of the recommended sites to inform the residents of the site characterization plan and to receive their comments.

After site characterization is completed, DOE will again evaluate each site and recommend one site to the President for the first repository. This recommendation will be accompanied by a final environmental impact statement in accordance with the requirements of the National Environmental Policy Act as modified by the Nuclear Waste Policy Act. The President will then recommend one site to Congress.

When the President recommends the site to Congress, which is estimated to be in early 1991, the host State or affected Indian tribe may issue a notice of disapproval that can be overridden only by a resolution of both Houses of the U.S. Congress. If the notice of disapproval is not overridden, the President must submit another repository site recommendation to Congress within 12 months. If no notice of disapproval is submitted, or if the notice of disapproval is overridden, then, as prescribed by the Act, the site designation is effective and DOE will proceed to file an application with the Nuclear Regulatory Commission to obtain a construction authorization for a repository at that site.

The process for selecting the second repository involves a similar screening process as described above for the first repository and lags the first repository schedule by about five years. DOE may consider sites identified as potentially acceptable but not nominated for the first repository, sites found potentially acceptable from rock formations not previously studied in the first repository selection process, and sites characterized but not chosen for the first repository site.

MONITORED RETRIEVABLE STORAGE

The need for and feasibility of Monitored Retrievable Storage (MRS) facilities has been studied. Storage concepts have been selected and designs developed.

On April 25, DOE identified three candidate sites to be included in the site-specific proposal required by the Act. All three candidate sites are in Tennessee and the preferred one is the former Clinch River Breeder Reactor site. The other two alternative candidate sites are the DOE Oak Ridge Reservation and the former Tennessee Valley Authority reactor site at Hartsville, Tennessee. Congress has not authorized construction of an MRS facility, but has directed DOE to evaluate MRS and prepare a proposal. A proposal is now being completed for submittal to the Congress.

DEFENSE HIGH-LEVEL WASTE

In August 1984, DOE issued a draft evaluation of the use of disposal capacity at the civilian repositories for disposal of high-level waste resulting from defense activities. Based on the draft evaluation, the only factor that results in a significant advantage for either option -- disposing of commercial high-level waste and defense high-level waste in the same repositories or in separate repositories -- is cost efficiency. DOE completed its final evaluation and concluded that due to the clear cost advantage to be gained by disposing of defense high-level wastes in a combined commercial and defense repository, combined repositories are the appropriate option. This recommendation was made to the President and on April 30, the President concurred in this recommendation in a memorandum to the Secretary of Energy. The Act clearly states that costs resulting from permanent disposal of defense high-level waste shall be paid by the Federal Government into the Nuclear Waste Fund.

ALTERNATIVE APPROACHES TO MANAGING AND FINANCING WASTE MANAGEMENT

The Act requires the Secretary to undertake a study with respect to alternative approaches to managing the construction and operation of all civilian radioactive waste management facilities, including the feasibility of establishing a private corporation.

In December 1984, the 13 person advisory panel -- Advisory Panel on Alternative Means of Managing and Financing -- appointed by the Secretary, completed a year's study and submitted a report to the Secretary. The principal findings of the panel are that the funding mechanism is adequate to achieve program success and that consideration should be given to establishing a Federally-chartered corporation to carry out the management of repository construction and operation. The report was submitted to Congress on April 18, 1985.

RESEARCH AND DEVELOPMENT ACTIVITIES

The Civilian Radioactive Waste R&D program is comprised of a series of cooperative agreement activities that are designed to advance the research objectives of the Nuclear Waste Policy Act. Some of the R&D programs were in progress prior to passage of the Act and others are new initiatives. All of these activities have now been integrated to avoid duplication and to complement the total waste management system.

DOE budgets for spent fuel storage development, alternative methods of disposal and generic repository research, development and demonstration activities outside the Act.

In February 1984, DOE signed a contract with Nuclear Fuel Services, Inc. to demonstrate, under a cost-sharing arrangement, cask transportation and dry storage. And in March 1984, DOE entered into cooperative agreements with the Virginia Electric and Power Company (VEPCO), Richmond, Virginia, and the Carolina Power and Light Company (CP&L), Raleigh, North Carolina, to participate in a demonstration of dry storage of spent fuel.

DOE has also provided rod consolidation equipment to the Tennessee Valley Authority (TVA) for a small scale demonstration. Another cooperative agreement is currently being negotiated with Northeast Utilities Company of Hartford, Connecticut, to demonstrate rod consolidation on a large scale.

DOE is conducting and participating in international research and development including investigations of alternative means and technologies for the permanent disposal of high-level waste. The subseabed disposal concept is the only alternative currently being studied in detail. By 1990, determination will be made of the technical, engineering, environmental and institutional feasibility of disposing of nuclear waste in the stable geologic formations of the deep ocean floor. In the meantime, DOE is cooperating with other nations in their assessments of subseabed disposal. International coordination is conducted through a Seabed Working Group of the Nuclear Energy Agency of the Organization for Economic Cooperation and Development.

The Act states that it is the policy of the United States to cooperate with and provide technical assistance to nonnuclear weapon states in the field of spent fuel storage and disposal. DOE and the Nuclear Regulatory Commission published a Joint Notice in the Federal Register in March 1983 and reissued the Joint Notice in April 1984 to solicit expressions of interest. To date, the Department of State has formally received responses from Brazil, CCNAA (Taiwan), Egypt, Mexico, Netherlands and the Republic of Korea. Several other nations are expected to make similar responses in the nearterm.

PROJECT DECISION SCHEDULE

A preliminary draft Project Decision Schedule has been prepared and is currently being reviewed by affected Federal Agencies. This schedule, required by the Act, is intended to lay out the optimum way to attain the operation of the waste management system and, therefore, includes a description and a sequence of deadlines for all Federal agencies required to take action.

INTERNATIONAL ACTIVITIES

As a further step in program integration, we have completed an evaluation of international aspects of the waste program and have developed a comprehensive strategic plan for international cooperation.

I would like now to highlight some of the major elements of the FY 1986 program and budget request. The discussion is divided into two parts which coincides with the two separate budgets managed by the Office of Civilian Radioactive Waste Management: The Nuclear Waste Fund Program; and the Civilian Radioactive Waste Research and Development Program.

THE NUCLEAR WASTE FUND PROGRAM

REVENUE SOURCES

To finance the nuclear waste disposal program, the Nuclear Waste Policy Act of 1982 established the Nuclear Waste Fund. The Fund receives all the revenue the Department collects from generators of civilian spent fuel and high-level nuclear waste.

The main source of revenue for the Fund is the one mill per kilowatt hour fee charged for all electricity generated beginning April 7, 1983, by the commercial nuclear power reactors. High-level radioactive waste and spent fuel generated prior to April 7, 1983, is subject to a one-time fee that is equivalent to an average charge of one mill per kilowatt hour. The utilities have three payment options and must decide by June 1985 as to which payment option they will select.

As mentioned earlier, some utilities have indicated they may choose the payment option whereby payment would be made as a one-time fee by June 1985. This could result in payments of approximately $770 million. If these monies are received in 1985, DOE could repay the debt transferred to the Fund since enactment of the Nuclear Waste Policy Act. This debt is approximately $258 million.

It should be noted, however, that the intent expressed by some utilities to pay the one-time fee by June 1985 is not binding at this time. However, all utilities must choose their payment option prior to June 1985. If the entire one-time fee were paid by June 1985, it is estimated to be about $2.3 billion. For that which is not paid by June 1985, the amount will increase as interest is applied for utilities which choose to defer payment.

For disposal of defense waste in a commercial repository, the Federal Government will pay a fee equivalent to that paid by utilities. This use of the repository will provide additional revenue for the Fund. The amount of the additional revenue is unknown at this time and is not included in our revenue estimates. We are developing a Memorandum of Understanding with DOE's Office of Defense Programs to be used as the vehicle in determining an equitable cost-sharing method.

Other fees for DOE-owned fuel which is not defense related will also be deposited into the Nuclear Waste Fund. Currently, DOE is surveying all its programs to establish how much fuel will be emplaced in a repository and how much DOE owes to the Fund. These additional revenues are also unknown at this time and are not included in the revenue estimates.

The revenue projections based on the one mill per kilowatt hour fee are shown in Table 3.

TABLE 3

NUCLEAR WASTE FUND REVENUE PROJECTIONSa/
(In Thousands)

FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988
$73,580 (actual)	$329,539 (actual)	$1,120,300	$401,100	$454,300	$504,300

a/ Includes one-time fee payments in FY 1985 and FY 1988.

REPOSITORY PROGRAM

(1) First Repository:

The FY 1986 budget request for activities associated with the first repository is $436.8 million. The FY 1987 estimate is $641.7 million; and the FY 1988 estimate is $486.7 million.

The funding for the first repository is mainly required for extensive site characterization drilling and testing, start of exploratory shaft construction and intensive engineering tests and analyses to support waste package and repository designs.

The major programmatic milestones associated with the schedule for the first repository are as follows:

Milestone	Calendar Year
o Nominate at least five sites and recommend three candidate sites to President for characterization	1985
o Issue Site Characterization Plans (SCP) for the three candidate sites	1985-1986
o Begin construction of first exploratory shaft	1986
o Issue Final Environmental Impact Statement	1990
o Recommend first repository site to President	1990
o Recommend first repository site to Congress	1991
o Submit construction application to NRC	1991
o Receive from NRC Construction Authorization	1993-1994
o Begin Phase I Operations	1998

The FY 1986 activities included in the $436.8 million are as follows:

o Begin site characterization activities at each of the three candidate sites. Conduct tests and analyze data to resolve issues for waste isolation most pertinent for the site or sites being investigated. Conduct drilling and testing of surface-based boreholes, logging, geologic field studies, geophysical surveys, long-term monitoring in wells to resolve site suitability issues and to incorporate into updated Site Characterization Plans (SCP). Analyze site and regional hydrology in more detail using data obtained from tests of hydrologic boreholes along assumed flow paths. Continue site environmental characterization and socioeconomic evaluations. ($122 million) o Begin construction of exploratory shafts in basalt and tuff. (Construction of exploratory shaft in salt to begin the following year.) Two shafts are planned for each site. Two shafts are required to provide an access to the repository horizon for site characterization and to meet ventilation, safety and emergency egress requirements. ($106.8 million)

o Conduct site-specific engineering tests at the three candidate sites including evaluations of rock mechanics, sealing concepts, shaft and tunnel excavation methods and waste emplacement alternative methods. Conduct repository conceptual design studies. ($59.8 million)

o Conduct regulatory and institutional activities. Issue initial basalt and tuff SCP's. Coordinate activities with the NRC, the U.S. Geological Survey (USGS), the Environmental Protection Agency (EPA) and appropriate State agencies and Indian tribes. These funds also provide the resources to conduct the program under an open information policy and afford the State and local governments and Indian tribes the opportunity to participate in the decisionmaking process. Provide financial assistance to affected States and Indian tribes. These funds would be used to allow the States and Indian tribes to study, determine, comment on, and make recommendations regarding possible health, safety, environmental, social and economic impacts of a repository. Conduct public meetings, public hearings, tours and briefings; prepare publications; etc. ($41.9 million) o Continue waste package design and development for the three candidate sites. Continue advanced conceptual design of the waste package. Conduct site-specific geochemistry and materials interaction studies. Corrosion analysis and waste package welding will also be studied. Continue studies of copper and copper alloys in an effort to evaluate the suitability of this material for canisters at tuff and basalt sites. At the close of FY 1986, these studies will provide sufficient data for the Department to decide on the viability of copper as a potential waste package material. ($38.9 million)

o Develop representative models for the performance of a repository site. Analyze groundwater flow systems to assess repository performance. Continue data base management, documentation and implementation of system engineering plans and other system engineering analyses. ($20 million)

o Continue to operate and maintain test facilities to conduct studies of rock mechanics and the effects of heat on rock and canister materials. Continue to support cooperative studies with foreign governments, especially at the Asse salt mine in West Germany. Access to the Avery Island salt mine in Louisiana will be maintained for possible study of salt and engineered barrier materials interaction. ($3.9 million)

o Complete land acquisition for construction of exploratory shafts in salt. ($12.2 million)

o Provide support for project management in developing and updating project management plans, operation of project cost and schedule control systems, management of subcontractors, operation of a quality assurance program, etc. ($31.3 million)

The FY 1987 and FY 1988 estimates of $641.7 million and $486.7 million, respectively, will support full site characterization at the three recommended repository sites and shaft procurement and construction at those sites as well as waste package and repository development and design efforts.

(2)Second Repository:

The FY 1986 budget request for activities associated with the second repository is $43.9 million. The FY 1987 estimate is $97.5 million; and the FY 1988 estimate is $102.1 million.

The decision points for the second repository program are spaced about five years from those for the first repository. The FY 1986 request supports the Presidential site recommendation for the second repository which is targeted for 1997.

Currently, the Department is conducting studies in crystalline rock in three regions -- the North Central, the Northeastern and the Southeastern regions -- to identify potentially acceptable sites for a second repository. Other studies of sedimentary rock bodies are being conducted to determine if those media may contain potentially acceptable sites. The major milestones leading to the site recommendation and license application decisions for the second repository are as follows:

Milestones	Calendar Year
o Issue revised draft regional characterization reports	12/84
o Issue final region to area screening methodology	4/85
o Issue final regional characterization reports	7/85
o Issue draft crystalline rock area recommendation report	11/85
o Issue draft crystalline rock area characterization plan	3/86
o Issue final crystalline rock area recommendation report	5/86
o Issue final area characterization plan and initiate crystalline rock area phase field investigations	9/86
o Recommend sites to President for characterization	1991
o President recommends repository site to Congress	1997
o Submit license application to NRC	1997
o Receive construction authorization from NRC	1999

The FY 1986 activities included in $43.9 million are as follows:

o Complete area recommendation report and area characterization plan. Collect and analyze regional-level data to assist in preparation of the Area Characterization Plan. Monitor progress of other projects, including those in other countries, in obtaining geologic, hydrologic, environmental and socioeconomic data. Prepare for field investigations and more detailed, specific geologic, environmental, transportation and socioeconomic studies. ($21.8 million)

o Conduct institutional activities, including workshops, meetings, public information and education activities. Continue Federal/State assistance through the issuance of grants. ($6.4 million)

o Establish area phase decision methodology and expand technical data base system. Issue decision methodology to States. Conduct preliminary performance assessment on the initial set of candidate areas to assist in area characterization and screening. ($3.7 million)

o Conduct initial repository conceptual design studies and continue engineering support for area-phase data collection. ($1.5 million)

o Complete current testing in the Stripa mine project. Continue tests at Grimsel facility and the Canadian Underground Research Laboratory (URL). Participate in URL construction activities and the Atikokan Flow Systems Study. Continue tests at the Colorado School of Mines and initiate field operations at Climax. ($3.7 million)

o Initiate efforts for land access for Area Phase Field Studies. ($1 million) o Prepare guidance on waste package design and performance characteristics to assist the area characterization activities. ($1.1 million)

o Provide support for project management, including implementation of cost/schedule control systems, developing and maintaining a quality assurance program and for overall planning, coordination and management. ($4.7 million)

The FY 1987 and FY 1988 estimates of $97.5 million and $102 million, respectively, will support field investigations, initial activities to support preparation of environmental assessments and site characterization plans, grants to affected States and Indian tribes, and State and public interactions including workshops and public hearings.

MONITORED RETRIEVABLE STORAGE

The FY 1986 budget request for MRS is $12.9 million. The FY 1987 estimate is $13.6 million; and the FY 1988 estimate is $18.7 million.

We believe an MRS facility should be an integral part of the total waste management system and we consider it an essential element in achieving overall system objectives. To support this position, DOE requested authority from Congress to reprogram $8.9 million for FY 1985 to allow the design and siting work necessary to present a plan for Congressional approval that reflects this concept. This request was recently approved.

DOE has studied the need for and feasibility of MRS facilities and is preparing a proposal for the construction of one or more MRS facilities. In January 1986, DOE will formally submit to Congress the detailed proposal which will include site-specific designs for an MRS facility. Two alternative designs will be prepared for each candidate site and the six design/site combinations will be included. An environmental assessment will be prepared. The environmental assessment and a needs and feasibility study will accompany the proposal.

It is our intent to prepare a proposal which will allow Congress to make an informed decision regarding the MRS and the integrated system; provide full opportunity for affected parties to express their views during proposal development; and provide the States, Indian tribes and public an understanding of the proposal which will allow their informed participation in the congressional decision-making process.

The FY 1986 budget request assumes Congress will authorize the Department to proceed with activities that are critical for deployment of an integrated MRS facility capable of meeting waste system needs and providing assurance of the Federal Government's ability to accept spent fuel and high-level waste.

The evaluation as to the need for and feasibility of MRS is critical to DOE's waste management system activities. Once authorized, DOE will proceed with siting, design, compliance with the National Environmental Policy Act (NEPA) and licensing activities. All activities will be proposed to enable completion and operation of facilities as soon as practicable and on a parallel basis with repository development.

Major activities included in the FY 1986 budget request of $12.9 million are as follows:

o Proceed with environmental data gathering and analysis at potential sites. Initiate scoping for the draft Environmental Impact Statement. ($4.3 million)

o Complete activities initiated in FY 1985 for procurement of a design/construction contractor and award contract. Further refine design and support systems needs. Initiate testing and evaluation of systems components and procedures to verify the design of critical elements of MRS facilities and provide data to support facility licensing. Implement licensing approach; conduct analyses and prepare topical reports on potential licensing issues. ($6.5 million)

o Conduct systems support activities to include establishing waste acceptance criteria, definition of shipping cask logistics requirements, monitoring storage needs projections, maintaining the MRS data base and performing system trade-off studies. This level also includes major quality assurance/quality control support to ensure that data obtained for design validation testing meets NRC requirements for future licensing. ($2.1 million)

The FY 1987 and FY 1988 budget requests of $13.6 million and $18.7 million, respectively, reflect a range of resources currently envisioned as necessary to conduct activities authorized by Congress in response to the MRS proposal. A definitive request is not made here in order not to prejudge the proposal.

TRANSPORTATION AND SYSTEMS INTEGRATION

The FY 1986 budget request for activities associated with Transportation and Systems Integration is $22.6 million. The FY 1987 estimate is $27 million; and the FY 1988 estimate is $18.4 million.

The funding request for FY 1986 provides the support required to develop adequate transportation and integrated systems for the shipping and management of nuclear waste among the various components of the disposal system.

The FY 1986 major activities included in the $22.6 million are as follows:

o Transportation: Work will be conducted in four major task areas: (1) systems acquisition, (2) institutional programs, (3) environment and economic analyses, and (4) technology development systems and testing support. Engineering design for new generation casks testing will begin. DOE will implement a Transportation Business Plan (issued in FY 1985 for public review and comment) to address institutional obstacles and plans and requirements regarding transportation route selection, prenotifications, safeguards, emergency response and equipment safety. This level of funding will also support the conduct of analyses of cask receiving and handling requirements and transportation networks to support MRS and repository programs. ($9.9 million) o Continue efforts leading to possible techniques, systems or facilities that can be employed at sites other than the repository to optimize overall system performance in terms of safety, cost effectiveness and schedule. Conduct analyses of specific systems concepts, including safety, cost and schedule implications, risk assessments and institutional issuances. Update and upgrade waste form data and acceptance schedules and develop feasibility of standard waste packages and/or canisters. ($12.7 million)

The FY 1987 and FY 1988 estimates of $27 million and $18.4 million, respectively, support continuing system acquisition, institutional programs, environmental and economic analysis, and technology development, data systems and testing support in the transportation area: and engineering development and systems integration.

PROGRAM MANAGEMENT AND SUPPORT

The FY 1986 budget request for program management and technical support is $55.2 million. The FY 1987 estimate is $56.3 million; and the FY 1988 estimate is $59.5 million.

The FY 1986 funding level of $55.2 million will support the following activities:

o Technical support for waste management activities by providing for (a) technical support integration, (b) development of standard materials characterization methods by the Material Characterization Center, and (c) supporting studies including fund management activities. ($33.8 million) o Provides for a total of 292 full-time equivalents (FTE's) for positions at headquarters and in the Operations Offices to manage funding, site investigation, technology development and institutional liaison associated with the technical management of the repository, MRS, supporting programs and the management of the Nuclear Waste Fund. ($21.4 million)

The FY 1987 and FY 1988 estimates of $56.3 million and $59.5 million, respectively, will provide for increased program management and technical support associated with site characterization activities at three candidate repository sites, intensified siting efforts in the second repository program, and a vigorous MRS program and increasing efforts in transportation systems development. Major emphasis will continue on developing an integrated cost-effective waste disposal system providing full protection of public health and safety and the environment.

CIVILIAN RADIOACTIVE WASTE R&D PROGRAM

Development and demonstration activities under the Civilian Radioactive Waste R&D Program are funded from general funds rather than funds collected from the utilities and deposited into the Nuclear Waste Fund.

The FY 1986 budget request for the Civilian Radioactive Waste R&D activities is $23.4 million.

I would like to briefly discuss the strategy and highlight the activities which we plan to undertake in FY 1986.

STRATEGY

DOE's Civilian Radioactive Waste R&D program efforts are to utilize all means directed or available through the Act or other authority to encourage and expedite the most efficient use of existing storage facilities and the addition of new capacity in a timely fashion. In addition, in accordance with Section 222 of the Act, DOE will continue research, development and investigations of alternative means and technologies for the permanent disposal of high-level radioactive wastes. In this regard, the subseabed disposal concept is the only alternative currently being studied. Generic R&D and supporting studies are also carried out in support of the waste program.

SPENT FUEL STORAGE R&D

DOE's spent fuel storage development program is to encourage and expedite the most efficient use of existing storage facilities and the addition of new, licensed capacity in a timely fashion. The FY 1986 budget request to support these activities is $8.9 million. FY 1986 activities included in this request are:

o Identify and analyze "mismatches" that may exist between the currently licensed commercial spent fuel shipping cask fleet and the handling capability ties at reactors that could potentially utilize Federal Interim Storage facilities.

o Obtain data from demonstrations of dual-purpose dry shipping/storage casks to aid utilities in the eventual licensing of such casks under NRC regulations. This would strengthen the technical basis for licensing spent fuel transportation in storage casks and would enhance DOE's ability to issue a certificate of compliance, or obtain an NRC license, for future shipment of storage casks after an extended storage period.

o Provide and update spent fuel information and analyses, other special studies and program support.

ALTERNATIVE DISPOSAL CONCEPTS

In accordance with Section 222 of the Act, DOE will continue research, development and investigations of alternative means and technologies for the permanent disposal of high-level waste. The FY 1986 budget request for these activities is $12.5 million and includes the following activities, all related to the international subseabed program:

o Continue cooperation within the Nuclear Energy Agency Seabed Working Group.

o Acquisition of high-resolution seismic survey maps of at least two site study areas.

o Deployment of the In Situ Heat Transfer Experiment (ISHTE).

o Completion of preliminary tests of sediment hole closure following simulated canister emplacement.

o Continued site-specific physical and biological oceanographic data acquisition.

GENERIC METHODS AND SUPPORT STUDIES

This program includes three main areas of effort: international program support, special technical reviews and waste management studies. The thrust of these efforts is to assure adequate international cooperation, provide an independent assessment of the technical adequacy of the program and evaluate potential alternatives which could improve the cost, schedule or technical aspects of the Civilian Radioactive Waste R&D programs.

The FY 1986 budget request for generic R&D and supporting studies is $1.7 million.

During FY 1986, DOE's international program efforts will support general and multilateral international agreements. Summary reports will be prepared on the various international programs of the numerous countries emphasizing the status and planning of international waste management activities. Proposed international cooperation activities on testing projects and exchange of information will be evaluated to ascertain the relative net benefit to program objectives. The information exchange contributes to the development of international consensus on the adequacy and safety of geologic disposal of nuclear waste.

In previous years, nonnuclear weapon states were solicited for interest in receiving technical assistance in response to Section 223 of the Act. The requests for assistance have addressed both the technology of spent fuel storage and disposal. We anticipate that additional countries will participate in this program in FY 1986.

DOE will continue to support special technical reviews conducted by the National Academy of Science Board of Radioactive Waste Management and evaluations of rock mechanics and tunneling techniques performed by the NAS Committee on Tunneling Technology assisted by the Department of Transportation and the Bureau of Mines in support of waste management activities. DOE will also support fellowship and university programs in the nuclear waste management area.

PROGRAM DIRECTION

The FY 1986 budget request for program direction is $325 thousand. At this level, five full-time equivalents would be funded to manage the Civilian Radioactive Waste R&D programs. The personnel required include administrative and technical personnel who manage a broad range of activities which includes research, development, demonstration, industrial involvement and international programs.

In summary, Mr. Chairman, the FY 1986 budget request for spending authority under the Nuclear Waste Fund and for appropriations under the Civilian Radioactive Waste R&D budget are designed to carry out an integrated waste management program in an efficient and effective manner and to achieve the 1998 mandate of the Nuclear Waste Policy Act, that is, to have in place a comprehensive and functional waste disposal system to begin receiving spent fuel.

This concludes my remarks in support of the FY 1986 Nuclear Waste Fund and R&D programs. I shall be pleased to answer your questions at this time.

Senator DOMENICI. Did we make whatever additional remarks you wanted a part of the record?

Mr. RUSCHE. Sir?

Senator DOMENICI. Did you have anything in addition that you wanted to be made part of the record?

Mr. RUSCHE. Yes, indeed. I have a much larger statement which we have submitted for the record, and I would appreciate it if you would include that for the record.

Senator DOMENICI. Without objection, it will be made part of the record.

Now, as I understand it, Mr. Vaughan and Mr. Rusche, the other witnesses are here to answer questions, but they have no testimony.

Mr. VAUGHAN. That is correct, sir.

Senator DOMENICI. All right. I have a couple and then we'll begin yielding quickly so everyone will get a chance to inquire.

Mr. Vaughan, I have seen a recent study that Sandia Corp. completed that indicated that United States reactor experience shows that there are many more unplanned shutdowns than the Europeans or Japanese plants experience, and that the majority of these unplanned shutdowns are due to problems in the balance of plant, rather than the reactor system itself.

Within your improved light-water reactor development program, are there any plans to address these balance of plant reliability problems?

Mr. VAUGHAN. Senator, that is one of the areas along with others that we would plan to look at in that effort, including the total integration of the control of the plant from the control room as well as reliability of the interfaces between the secondary and primary systems.

We've gotten far too complex and the simplifications that we can achieve I think would serve to operate the reactors more reliably.

Senator DOMENICI. Well, it appears to me that if this is a fact and if the shutdown problem is principally in the balance of plant rather than the reactor system itself, that clearly the public doesn't understand the difference and it's all the reactor as far as they are concerned. And I personally think it's urgent that we do what we can, and that you keep us advised on what's being done to improve that aspect of plant reliability.

I assume you agree with that, do you not?

Mr. VAUGHAN. I do agree that it's important that the public understand, and I certainly would be pleased to keep you advised as we progress.

Senator DOMENICI. Mr. Vaughan, I'm interested and supportive of the activities to develop the nuclear powered energy sources for space applications. However, I would appreciate it if we could get the record straight once and for all that the development work associated with SP-100 and the multimegawatt space reactor system is a civilian reactor development program conducted within the Office of Nuclear Energy as opposed to the defense programs within the DOE.

Am I correct in that statement?

Mr. VAUGHAN. Senator Domenici, you are correct in that the programs are conducted in the Office of Nuclear Energy. Our interfaces are with both NASA and the Department of Defense, including the SDI activity. But these are energy sources, not weapon sources.

When we originally prepared the budget, at the suggestion of OMB we included them in a line under the overall atomic energy defense activities. Subsequent to that initial submission based on discussions with various committees in the House, as well as the staff of the various Senate committees, it was concluded that oversight of those activities more appropriately belonged with the House Science and Technology Committee in the House and your committee because they were a part of our efforts.

Our revised authorization bill submitted early in April clarifies that.

Senator DOMENICI. One further question on the SP-100. When will the site selection be completed for the ground testing of the SP-100 and what factors are going to be considered in the choices?

Mr. VAUGHAN. We anticipate completing that site selection in July of this year. There are five candidate sites, all of which have positive attributes, all of which are located on DOE sites that have been involved in related work. One is in Senator Hecht's State, one is in Senator Evans' State, one is your State, one's in Senator McClure's State, and the fifth one is in Tennessee.

And so there's obviously real interest among all of you as to where this is located. The criteria include capability of the contractors to provide suitable expertise and capabilities to conduct the tests, the suitability of facilities, the integration of that effort with the missions to be accomplished, and obviously the cost and effort that would be involved in trying to utilize existing facilities and modify them, rather than build them from the ground up.

We've got a committee doing a detailed look at all of the sites against a set of criteria which were jointly agreed to by the steering committee, which is comprised of the Department of Energy, Department of Defense, and NASA. The Department of Energy does have the lead for the site selection.

Senator DOMENICI. It's going to be a tough choice, isn't it?

Mr. VAUGHAN. It does indeed have some interesting aspects. Senator McClure is missing, but his——

Senator DOMENICI. Yes. He isn't here, so——

Mr. VAUGHAN. His agents are here.

Senator DOMENICI. Oh, they are.

Senator EVANS. The gray shadow overhangs.

Senator DOMENICI. We were going to strike that from the list, weren't we, Bennett? [Laughter.]

I have a number more, but I'm just going to ask one and then yield to Senator Johnston. This is for you, Mr. Rusche.

Last week the President approved the DOE report which says that we should put defense high-level waste in the civilian repository or repositories. That's news of some interest in the country, and certainly in my State it's of interest because there is still some confusion and misunderstanding about whether high-level waste would be placed in the WIPP facility, even though the law prohibits that by statute; the authorization language prohibits it.

Some would say that the DOE still intends to put it there. Under the Nuclear Waste Act, the President was required to make a finding. If he found as he did, then the high-level military and civilian will be placed in the same repository about which you have already testified in terms of one of the three sites—Nevada, Texas, or Washington as your three you are looking at.

So that decision has been made that they will be placed together and it obviously will be in one of the new sites.

I have a question on cost. How do you intend to bill the Federal Government for its share of the repository? The Federal Government now, if the defense waste is going to go there, that's different from the statutory language which would basically assess the industry.

So how are we going to, from the beginning and then later on, bill the Federal Government—namely, the Department of Defense—for its share?

Mr. Rusche. Mr. Chairman, the question of assessing the cost of the operation I believe is made very clear by the act in terms of its principle; namely, that the full cost of any of the sources of waste should be borne by the generators. So we will follow that principle, and we have begun an extensive set of discussions with the Assistant Secretary for Defense Programs, and we intend to address the issue in a very straightforward manner.

I do not have the answer in hand today, since the President's action was just final on April 30. We are beginning a fairly intensive set of discussions, but I can assure you that to the best of our ability, and I can assure you that you'll have a chance to review our conclusion, we will in effect ask the program to pay its pro rata share of the costs of the repository both prospective and retrospective.

Senator Domenici. And that is the Department of Defense that you are going to begin to talk with.

Mr. Rusche. It'll be the Federal Government. Most of that waste is generated by DOE in production facilities. The Assistant Secretary for Defense Programs in DOE is the person with whom I am beginning such discussions now.

Senator Domenici. Well, we have some confusion because that part of DOE which we are speaking of is part of the DOD overall budget, but we'll—so long as we understand that.

Mr. Rusche. Yes, sir.

Senator Domenici. I would just want to comment on that aspect. I think those who worked on that law, including the distinguished Senator from Louisiana who is here, and a number of others, should be very proud of the fact that we always thought the defense high-level waste should be mixed with civilian, since we are all trying to put it away forever. We never could get Defense to agree, so we just said we'd do it this way and send all the findings to the President.

It worked out right. He found that there was no reason to build two. We have enough trouble finding one. So I'm hopeful that we won't get it mixed up in terms of cost now because then we'll have an argument from the civilian side that they shouldn't be paying the whole thing.

Mr. Rusche. I can assure you that we will do our best to avoid any such arguments, and it is our intent to follow the principal of generator pay the cost.

Senator DOMENICI. Senator Johnston.

Senator JOHNSTON. Thank you, Mr. Chairman. I have a written statement I'd like to put in the record at this time.

[The prepared statement of Senator Johnston follows:]

STATEMENT OF SENATOR J. BENNETT JOHNSTON

HEARING ON DEPARTMENT OF ENERGY NUCLEAR PROGRAMS AND NUCLEAR WASTE ACTIVITIES

MAY 13, 1985

THE HEARING TODAY COVERS A NUMBER OF IMPORTANT ACTIVITIES OF THE DEPARTMENT OF ENERGY IN THE FIELD OF NUCLEAR ENERGY. IN THIS STATEMENT I WOULD LIKE TO SUMMARIZE WHERE I THINK WE ARE WITH ONE OF THE MOST IMPORTANT OF THESE ACTIVITIES: NUCLEAR WASTE MANAGEMENT.

I WANT TO CONGRATULATE BEN RUSCHE FOR THE LEADERSHIP HE HAS BROUGHT TO THE THE OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT. THAT LEADERSHIP HAS PRODUCED A NEW AND PROMISING DIRECTION FOR THE PROGRAM. HE HAS FOUND A WAY TO INTEGRATE THE MONITORED RETRIEVABLE STORAGE CONCEPT WITH THE BASIC REPOSITORY PROGRAM.

THE SYSTEM THAT WILL RESULT FROM THE INTEGRATION OF MRS AND REPOSITORIES WILL LEAD TO A MUCH STRONGER NUCLEAR WASTE MANAGEMENT PROGRAM.

THE PROGRAM WILL BE STRONGER, FIRST AND FOREMOST, BECAUSE WITH AN MRS IN THE SYSTEM THE FEDERAL GOVERNMENT CAN DELIVER ON ITS PROMISE TO TAKE OVER THE MANAGEMENT OF SPENT FUEL AND HIGH-LEVEL WASTE IN A TIMELY FASHION.

SECOND, WITH AN MRS IN THE SYSTEM, A FAR MORE RATIONAL TRANSPORTATION AND HANDLING SYSTEM CAN BE EMPLOYED. TRANSPORTATION IS THE MAIN POINT OF IMPACT OF THE PROGRAM WITH THE PUBLIC. REDUCING TRANSPORTATION IMPACT WILL REDUCE THE BURDEN OF THE MOST SENSITIVE PART OF THE PROGRAM FOR THE AVERAGE CITIZEN.

AND FINALLY, WITH AN MRS IN THE SYSTEM THERE IS INSURANCE THAT, IN THE EVENT THAT THE OPENING OF THE FIRST REPOSITORY IS DELAYED - SOMETHING THAT IS CERTAINLY PROBABLE, THE TOTAL COST OF THE PROGRAM CAN BE REDUCED BY PROVIDING LOW-COST TEMPORARY STORAGE AT THE MRS IN PLACE OF HIGH-COST AND DISRUPTIVE STORAGE AT INDIVIDUAL REACTOR SITES.

THESE ARE FAMILIAR FACTS FOR THOSE OF US WHO HAVE BEEN FOLLOWING THE NUCLEAR WASTE PROGRAM CLOSELY. HOWEVER, I DO NOT THINK THAT THE NEW STRUCTURE OF THE PROGRAM IS VERY WIDELY APPRECIATED BY THE PUBLIC OR BY ALL OF THE CONGRESS. WHEN THE ADVANTAGES OF THE INTEGRATED MRS-REPOSITORY SYSTEM ARE UNDERSTOOD, I'M CONFIDENT THAT THERE WILL BE SUPPORT FOR THIS SYSTEM APPROACH. WE WILL CROSS THAT BRIDGE EARLY NEXT YEAR WHEN THE DEPARTMENT SUBMITS THEIR MRS PROPOSAL TO CONGRESS FOR APPROVAL.

BETWEEN NOW AND THEN AN EDUCATIONAL PROCESS MUST TAKE PLACE.

IN THE COURSE OF THIS PROCESS, WE SHOULD MAKE IT VERY CLEAR THAT THE MRS IS A ONLY A WAY STATION IN THE SYSTEM. THERE HAS BEEN NO CHANGE IN THE BASIC POLICY OF DISPOSING OF NUCLEAR WASTE IN REPOSITORIES.

NUCLEAR FUEL IS BROUGHT TO THE MRS FOR PACKAGING, HANDLING AND PREPARATION FOR BURIAL IN A DEEP GEOLOGIC FORMATION. THE FUEL IS NOT GOING TO STAY AT THE MRS. IT IS GOING TO GO TO A REPOSITORY. THE REASON WE HAVE AN MRS IN THE SYSTEM IS THAT THE PRESENCE OF THE MRS MAKES THE SYSTEM BETTER - MORE CREDIBLE, MORE PREDICTABLE, EASIER TO MANAGE, SAFER, AND LOWER IN COST.

THIS IS THE CASE DOE, THE UTILITIES, AND EVERYONE INTERESTED IN THE ESTABLISHMENT OF AN EFFECTIVE NUCLEAR WASTE MANAGEMENT SYSTEM MUST MAKE BETWEEN NOW AND THE TIME CONGRESS FINALLY VOTES ON THE MRS PROPOSAL. THE MRS IS NOW ON THE CRITICAL PATH TO THE ESTABLISHMENT OF THE FEDERAL NUCLEAR WASTE MANAGEMENT SYSTEM. IT IS THE FIRST PART OF THIS SYSTEM THAT WILL BE IMPLEMENTED. THEREFORE WE ARE GOING TO HAVE TO WORK MUCH HARDER ON THE MRS THAN WE HAVE IN THE PAST TO BRING THE SYSTEM TO FRUITION.

I STAND READY- AS DO OTHER MEMBERS OF THIS COMMITTEE - TO HELP IN ANY WAY APPROPRIATE TO SEE THAT THE MRS-REPOSITORY SYSTEM IS SUCCESSFULLY IMPLEMENTED SO THAT THE PROMISE OF THE NUCLEAR WASTE POLICY ACT OF 1982 IS ACHIEVED.

Senator JOHNSTON. I'd like to first congratulate Secretary Vaughan for an excellent statement and, I think, a proper endorsement of nuclear energy and assessment of the problems in nuclear energy.

We do indeed need to basically restructure the way we think about nuclear energy, the way we manage it in this country if we're going to keep the option open, because the option is rapidly closing, and for no good reason.

I just returned from Japan about 3 weeks ago, where I spoke to the Japanese Atomic Industrial Forum. We met not only the Japanese, but people from around the world in nuclear energy. And the nuclear option, of course, is alive and well all over the world, particularly in Japan and France where nuclear reactors have proven to be safe, efficient, low cost, and are being built apace in those countries.

Their safety record appears to be, at least by the number of scrams they have, superior to ours. While we take 12 to 14 years to build a nuclear reactor with costs of $1 million or $2 million a day for the interest while the delay goes on, they build them in 5 years, maybe even less occasionally, with a superior safety record.

It seems that our system is designed by and for the lawyers and produces only delays in cost, and not a very good safety record. And I think you in the Department and we in the Congress, and anybody else who has a good idea, needs to figure out how practically we can get the system redone to preserve that option.

I've done some studying on the question of what we're going to need in terms of new electric supply, and I think whatever those needs turn out to be—and they are always difficult to assess—we're not going to have enough at the rate we're going. We're not building enough coal plants. There have been more coal plants canceled than put on line, and certainly the same is true of nuclear energy.

And I believe also, Senator Ford, that we need to have an alliance between coal and nuclear so that we can get plants built, period. Some people think we're just foreclosing the nuclear option. The fact is we're foreclosing the electric option.

The problem is, if we get short, we're going to be short for a long time because you can't just say abracadabra and have a plant come out of the ground immediately.

Now, in terms of what we need to do for the nuclear option, I think the thing that is absolutely on the critical path is nuclear waste. All these other things are important: redo licensing, have generic design, all of those things. But nuclear waste is on the critical path.

And I want especially to congratulate or commend Ben Rusche for the excellent job he's been doing. It's very, very difficult, as you know. There are gigantic forces out there that will oppose whatever you do. You know, you do it this way, they'll say no, you should have done it that way; you do it that way, they'll say no, you were right the first time; why did you change?

And they're going to be out there, big sharks, big barracudas, trying to undermine you in what you're doing. But I think we're right on path, right on track, and we cannot allow this train to get derailed.

Now, to that purpose, I think one of the first things we need to do, continue to do, is to reassure people that monitored retrievable storage [MRS] is not in lieu of the permanent repository. It is really step one on the way to getting toward the permanent repository, which will allow us much better to manage those nuclear wastes, to cool them off, to reduce the difficulties in scientific terms geometrically, because you put in cool rods, say, after 50 years or 20 years or whatever the period you will choose to keep then in the MRS; it is a much simpler problem. You won't then produce molten salt or cracked granite or basalt or whatever it is, and your levels of radioactivity, of course, will be lower by a geometric factor.

In any event, we need to reassure those that by proceeding with some haste, with some dedication to time to get that built, that we're not trying to do this in lieu of the permanent facility. And I'll try to do my part in saying that there should be no great suspicion out there that MRS is a substitute for the permanent repository. Some of my friends over in the House think that's been my agenda for a long time; it has not; and I know it is not yours, and I think you've tried to reassure on that, Mr. Rusche, and I urge you to continue to do that.

Now, you're going to have a proposal up here to the Congress in January 1986 as I understand it.

Mr. RUSCHE. Correct.

Senator JOHNSTON. Now, what you're going at right now is the cask in the ground, individual casks—or have you decided on a configuration?

Mr. RUSCHE. If you recall, Senator, we did—or the Department did—some studies before I arrived which identified two designs. One was a cask above ground and the other was a cask in the ground. Those two designs are on the shelf and certainly workable.

During the next several months, in preparation for the proposal in January, we will be looking at those two as the prime candidates and perhaps some variation on those as the bases for the proposal to Congress in January.

Senator JOHNSTON. Well, I certainly don't want to try to second-guess the scientists who ought to be the ones to design that. It would seem to me, just from the optics of it with the Congress and with the public, that we could come up with something that sounds better and looks better than just a cask, just burying a little cask individually in the sand out somewhere—some system of underground system with caves or whatever.

Do you plan to have an underground series of caves where you take the cask, or do you just plan to dig a hole with each one?

Mr. RUSCHE. The current designs, both of which I've referred to, do not envision subsurface major works; that is, all of the work would be done from the surface. I think that that's one of the features that has the potential for allowing us to proceed on the pace that we're talking about.

If we begin to consider subterranean or below-the-surface designs which we do not now have on the drawing board, I think we would incur additions in time for limited benefit. And I realize the optical value of your comment, and we certainly will not allow that to go unheeded. But I think we need to balance that against the practical performance of the system. And I believe the data that we have will support the performance as being adequate.

Senator JOHNSTON. Senator Domenici says how do the French do it? Well, the French I think glassify their waste and put it down in a long tube which has convection cooling; isn't that correct?

Mr. RUSCHE. The French do not have any permanent method. Their shorter term methods generally do involve vitrified material. In COGEMA, for example, they essentially put them in a hole in the floor.

Senator JOHNSTON. It's a long tube where you put those milk cans, a number of them like——

Mr. RUSCHE. Yes, some of the tubes are long enough to contain more than one, but most of them are relatively straightforward; in effect, a hole in the floor as it were, a hole in the surface with a cap on it that provides adequate shielding and a basis for appropriate monitoring.

And that's essentially the approach that we are taking. The COGEMA facility, for example, does have a roof over it, and some would argue that that makes it look prettier. From a functional standpoint, I don't think it adds a whole lot, but it may well turn out that that's what we'll want to do as well.

Senator JOHNSTON. Well, you have in mind just burying these things right directly in the dirt?

Mr. RUSCHE. Not burying. Inserting into a receptacle which can receive an assembly, store it for a period, relatively short, have it withdrawn, and eventually dispatched then to the repository.

Senator JOHNSTON. Well, would you take the cask and put the cask in a receptacle, a tube or whatever?

Mr. RUSCHE. That's part of the design consideration underway now. Certainly the overpack we would hope to be able to put in and deal with only one time, and it may be that the cask itself would be emplaced in a receptacle. It may be that only the overpack would be removed, and then it would be placed in a cask for later shipment. But the simpler we can do it, the fewer times we have to handle it, the greater will be the improvement in the efficiency and safety of the system. So we're looking at trying to do each thing only once to the best of our ability.

Senator JOHNSTON. Well, I would urge you, as you get these preliminary designs, to show them around up here for the political optics of it and let's be sure it will sell, because we don't want to get out there on one limb and have people say oh, no, we can't do that; that will never work.

It may be like the dense pack. The dense pack might have worked, but it seemed up here that it would not work. It looked like a Rube Goldberg idea, and indeed the administration eventually rejected it on that ground. We don't want that to happen to the MRS.

Mr. RUSCHE. Couldn't agree more.

Senator JOHNSTON. Let me say one more thing. Now, there's going to be, necessarily, a lot of development that comes out of putting an MRS in a particular place. There's going to be jobs, there's going to be an investment, there's going to be other things. I would suggest that we begin to discuss those things so that people in South Carolina, if that's where we're going to put it——

Mr. RUSCHE. Tennessee.

Senator JOHNSTON. I mean Tennesse, excuse me—would begin to understand that this is going to be a very strong plus for the economy in those areas.

Mr. RUSCHE. Senator, we have done that in meetings with both the Governor and key members in the State. I've tried to use words that were not prejudgments, which I can't make yet, but to have the effect of saying that we intend to make this operation as much like a private business from the standpoint of producing revenue for the State and community as we can figure out a way to do under the various laws and constraints that we've got.

We intend to have in the proposal that we'll bring to you in January, an approach for doing that. And we certainly will have had many opportunities to talk about whether that approach or other versions ought to be considered. But your statement, I think, is very important; that this ought to be a good industrial community citizen, this operation, and we intend to see it so.

Senator JOHNSTON. Well, Mr. Chairman, I want to say again, Mr. Rusche has really done an outstanding job. He has provided the leadership in this area along with Secretary Vaughan, and I think it takes that kind of leadership in this very difficult area if we're going to ever just preserve what we've got in terms of nuclear energy. Otherwise, we're going to have a grand and glorious mess.

But I think we're going to work our way out of it with your leadership. Thank you.

Senator DOMENICI. Thank you very much.

Mr. RUSCHE. Mr. Chairman, I sure appreciate the comments of the Senator and all of you. It does take all of us, though, and I really appreciate your help.

Mr. VAUGHAN. And if I may add, Senator, I've certainly enjoyed having the opportunity to read your remarks that you made before the AIF in Japan. They are completely consistent with my views and views of the Department, and I think we're all committed to working together to achieving the objectives I think we both share.

So we appreciate your support.

Senator DOMENICI. How did they feel about him overseas, do you know? [Laughter.]

We don't really want—we don't want you to comment.

Senator JOHNSTON. Over here, they wanted me to stay.

Senator DOMENICI. Actually, I didn't ask him to—I didn't ask him how the French did it. What I really expected him to catch was that I've never been to France and he's been there many times, and that he——

Senator JOHNSTON. And I'm going back.

Senator DOMENICI. And he's going back. I may go some day. But he's also explained it here before, and I just never saw so many people present, and I wanted you to explain it again.

Senator JOHNSTON. Do you want me to do it a little slower? [Laughter.]

Senator DOMENICI. No, that's fine. Everybody understood. If I did, everyone did.

Senator Evans.

Senator EVANS. I thought this committee stayed at home. Mr. Johnston's going to Japan and France. I'm on the wrong subcommittees, I think.

Senator DOMENICI. Well, he does serve on another committee that frequently travels.

Senator EVANS. Mr. Vaughan, I've been concerned about our overall energy policies, particularly as they relate to energy research and development. I'm not sure we've got our money spread in the right directions. And I've been particularly a critic of putting as much as we have into synfuels and as little as we have into some alternative technologies.

And it seems to me that while it may be difficult now with the immediate surplus we seem to have in both electric energy and in other fuels, that those surpluses are not likely to last for any extended period of time and that we're foolish if we don't continue on parallel sources on research and development, and I'm particularly interested in what your view is of the breeder reactor as a potential part of the nuclear future or of our total energy future.

I recognize what's happened with the vote in the Senate on the Clinch River reactor, but that doesn't end all of our research. Where are we headed? And I guess I'm somewhat concerned along those lines that we seem to have a shrinkage in some of the current dollars at least that go into some of these research facilities.

When do you—the first question is, in your testimony you put the approximate date for commercialization, if we proceeded along the line of the breeder beyond the year 2000; that leaves a pretty wide open territory.

Would you like to be a little more specific? How far beyond 2000, assuming we did what could be done?

Mr. VAUGHAN. I think, Senator, that is going to depend on how well the demand materializes, because we could need another 100 to 200 gigawatts between now and the year 2000. If that starts to—if we get the nuclear option restored, as Senator Johnston and I were talking about, I think that will help to show that we do need to not only use, but to continue to conserve, our uranium resource.

And I would hope that not too long after the turn of the century, we may be back in the breeder business. That's why we feel it's important to keep our Base Technology Program going, to keep our lead in our fuels and materials development efforts, and to strengthen our ties with our overseas partners who, because of different constraints within their own countries, need to deploy the breeder sooner and have gone that path.

And it's just really impossible for me to pick a date at this time.

Senator EVANS. Would you say the date is more likely to be governed by economics rather than research?

Mr. VAUGHAN. Yes.

Senator EVANS. What do you anticipate the potential would be in the economics of nuclear reactors vis-a-vis the new generation light-water reactors or gas-cooled reactors versus breeder?

Mr. VAUGHAN. One of our objectives is to try to get the construction costs of all of these devices down in the range of between $1,000 and $1,500 per kilowatt electric delivered, because if we can't achieve that for the advanced reactors as well as light-water reactors, we're just not going to make it on economics.

Senator EVANS. If they're both in that same range in terms of capital outlay, is the breeder then likely to be more productive in terms of fuel use, maintenance, and operation?

Mr. VAUGHAN. I think in the long term it would be, but obviously to do that we would need to rejuvenate and resurrect at a faster pace some of the activities that we've had to curtail in tight budget times, particularly the front end and the back end of the fuel cycle.

We are continuing some of those efforts at a nominal pace, including capabilities for remote fuel fabrication and remote handling, all of which are associated with the application of the breeder technology.

Senator EVANS. With that in mind, do I understand correctly that you would—budget restrictions are going to cause you to restrict rather substantially the budget at the FFTF in carrying out precisely those kinds of research?

Mr. VAUGHAN. I'm going to let Dr. Wilcox respond to that.

Dr. WILCOX. Yes, Senator. There are budget limitations that we're dealing with. There will be decreases in terms of the number of personnel associated with FFTF, but in terms of its role and its position in leading us toward the things that have just been discussed, it still must remain in our focus and in our budget as one of the lead candidates for demonstrating some of the things that we're talking about: Economics of construction, passive safety, better control and communications systems that operate reactors.

Senator EVANS. It seems to me with the assurance that we are looking at alternative sources and we're trying to ultimately be governed by economics, aren't you tying a great big anchor on the breeder technology by restricting or reducing some of those key elements in research that are necessary to show its economic value?

Dr. WILCOX. Yes, sir. I concur; we are reducing some of those basic R&D costs associated with the technology. However, we're looking very carefully at maintaining those that point in the directions that we have taken with the alternate concepts, the innovative concepts, longer ranged fuels.

And we very seriously are considering the effect of when is too much too much in terms of cutback.

Senator EVANS. Mr. Vaughan, if we had an extensive breeder program in place now, as opposed to the typical light-water reactors, what would the nature of our waste disposal problem be?

Mr. VAUGHAN. Senator, I'm not sure I can give you a precise answer, but obviously——

Senator EVANS. Orders of magnitude?

Mr. VAUGHAN. The breeder clearly, as you well know, makes use of reprocessing: Reusing fuel, and taking the burned fuel and using the plutonium out of it. So I would say we would be down by a factor of four or five.

Senator EVANS. Ben, would you like to tackle that one?

Mr. VAUGHAN. It's not going to eliminate the light-water reactors in this country.

Senator EVANS. I understand all that. I'm just trying to get a sense of—and I think that it's important for people to understand what those relationships are. If you had just taken some fixed amount of electric power generation and you were doing it through light-water reactors of today's capabilities and you were doing it through a breeder reactor that was economic, what's the ratio of waste production?

Mr. RUSCHE. I can't give you an exact ratio, but let me offer a comment that might be helpful to us.

Clearly the volumes of material that might be involved if we were disposing of spent fuel directly would be very different. Obviously we don't use that approach with a breeder, so it would be in the mode of reprocessing. But I think we ought to be careful not to draw the inference that because we are reprocessing and using or extracting more energy from the fuel that we don't produce waste.

In essence, the amount of waste produced per fission is about the same. The one thing that you might point to is that we would have less long-lived material in the sense that we would continue to consume the plutonium in the process, and that might have a small effect on the repository. But I doubt per megawatt generated or per megawatt of thermal energy generated, the total amount would be all that different from a waste standpoint.

Now, I have not given great study to it, but just from the physics involved, I don't see how it could be very different, because for every fission we get, we get the same number of fission products. The volumes would be different because of the reprocessing, but that's not peculiar to breeding. That could be the case today if the economics drove it in that direction.

I don't believe the waste activity is a strong pusher, as it were, for breeding.

Senator EVANS. OK. Let me continue—I'll have a number of written questions, and I don't want to take an undue amount of time, but Mr. Rusche, Senator Johnston talked about MRS. And you in the testimony, I think, used the term "parallel basis with repository development."

If we ran into difficulties, as we well might in the timing of development of long-term storage, will MRS act as a holding pattern? Maybe is it possible that it would ultimately become a choice? If there are difficulties, if in the next 5 years we run into real difficulties on the geology or the other factors and find that none of the three sites that are going to be examined will prove sufficient, what do we do then? Or will MRS act as an alternative for some years pending the development of better techniques or new technologies for permanent waste storage?

Mr. RUSCHE. Well, it's clear that MRS is a short term, in terms of repository time, element in the system.

Senator EVANS. Identify "short term."

Mr. RUSCHE. Well, say tens to hundreds of years, rather than thousands of years or longer.

Senator EVANS. Presumably within tens to hundreds of years, you could conceivably develop new and better technologies.

Mr. RUSCHE. Well, it certainly would provide time. But I would like to hasten to point out that, one, I do not envision that becoming the case; and, two, that is not the role for the MRS that we have proposed. And I would point out that very likely in the proposal we bring to Congress, the amount of capacity that we ask you to authorize at the MRS will be small in comparison to the total amount of storage that would be required if MRS were to be viewed as an interim storage facility for such a long period of time.

I have no way of knowing what the future circumstances might be. Congress, the country, might conclude that were the case, but I'd like to reassure you and all Americans that if that becomes the case, it's clearly not a decision that we in the Department would make. It would be one that would be made only after considerable discussion with you and your own authorization.

Senator EVANS. I understand that, and that's perfectly appropriate. I guess, maybe to ask this question in a different way. What alternative, or are you looking at any alternative strategies if the work of the next 5 years indicates that none of the three sites to be examined would be adequate for long-term storage? Then what?

Mr. RUSCHE. We have a new strategy chapter in the mission plan that will be issued later this month. And let me see if I can quickly point out how we would go about viewing this.

First, we will ask Congress to authorize the MRS. If we found that 3, 4, or 5 years from now that we ran into some insurmountable problem with either the three sites or the concept, if Congress has authorized the MRS, it would be available for some intermediate period of time.

If Congress chooses not to authorize the MRS, we would have available both as a result of work currently underway and more work we will be doing, dry cask storage which could be employed for some indefinite, but not very cost-effective period at the utilities. And finally, if that approach either became too costly or inappropriate for whatever reason, continued storage in the fuel pools at reactors for an indefinite period is a possibility.

So we don't face a crisis. I think the crisis, if any, that we face is in the philosophy and the confirmation that this system in fact is a closed system and not open-ended.

So I hope that we do not—I have not communicated in any way the objective that MRS is other than a part of that operating closed system and not a substitute for a repository, because I think you, the Congress, have made the right choice for America; that such waste needs to be permanently disposed of in geologic repositories at the earliest time that we can make it.

Senator EVANS. I'll have some other questions, but I'll submit those, Mr. CHAIRMAN.

Senator DOMENICI. Senator Ford.

Senator FORD. Thank you, Mr. Chairman.

Mr. Vaughan, two items in the table on page 1 of your testimony are not detailed in your text. I'd like to have at least an overview of those if I could, and it's down in the third paragraph under uranium enrichment activities. All other, it says 238.7 million.

Mr. VAUGHAN. I'm going to let Mr. Longenecker respond to that.

Mr. LONGENECKER. Senator, those costs are primarily the gaseous diffusion plant operating costs, the cost of operating the GDP's, chiefly manpower for operation and maintenance at Paducah, Portsmouth, and Oak Ridge.

Senator FORD. All right.

Let's look at the other one then; under net energy supply research and development appropriation, $614.7 million.

Mr. VAUGHAN. The appropriation is called energy supply research and development appropriation, and that's just simply a subtotal of everything that's above it in the table, recognizing that the uranium enrichment account is a net zero appropriation.

Senator FORD. All right.

How much are you still paying TVA for power not taken, and how much does that add to the price of SWU?

Mr. LONGENECKER. This year the TVA demand charge, fiscal year 1985, is about $350 million. In fiscal year 1986, the budget described here, it is in the range of $400 million per year.

Senator FORD. Well, that's how much you're paying and not taking?

Mr. LONGENECKER. Yes, sir. That is demand charge for energy not taken.

Senator FORD. All right. How much does that add to the price of a SWU?

Mr. LONGENECKER. We'll be producing in fiscal year 1986 about 8 million SWU's. In that year it will be adding on the order of $50 per SWU.

Senator FORD. $50?

Mr. LONGENECKER. Yes, sir.

Senator FORD. Mr. Vaughan, on page 27 of your testimony, you touch on the transfer of closed low-level waste sites to DOE. When will the procedures for evaluation of proposals for transfer be completed?

Mr. VAUGHAN. Mr. Chairman, we expect to complete that by this fall.

Senator FORD. This fall? You're talking about October, November, sometime before the first of the year?

Mr. VAUGHAN. Before the first of next fiscal year, during this fiscal year.

Senator FORD. Well, that would be October 1.

Mr. VAUGHAN. Yes. Before October 1.

Senator FORD. Can you estimate then when transfer of sites will begin?

Mr. VAUGHAN. I really would like not to give you a specific estimate because a part of that whole process is going to depend on the separate process that goes on this year in terms of Congress approving the regional compacts and whether or not the dates for States to come together to form compacts are extended. So we're going to have to fit that into the total process.

Senator FORD. Well, let me ask you this question then. Do you foresee any particular regional problems in the formation of a regional low-level waste compact? And if a particular region does not develop a compact, what effect will this have on the region and the national program?

Mr. VAUGHAN. Well, Mr. Ford, as you recognize, that is not really under the Department of Energy's control because the formation of those compacts are being done in accordance with the Low-Level Waste Policy Act of 1980. And a number of those compacts are before Senator Thurmond's Judiciary Subcommittee for approval. The Department's role is to provide whatever technical assistance we can to provide technical assistance and help the States in forming those compacts, evaluating sites that they would choose, and that nature.

Senator **Ford**. Well, of course, you say you have no control over it, but surely you're following it because that's part of your program to see how it's going to fit. Do you see any particular problems? Do you see any region of the country that might be creating a problem that would hold up the national program?

Mr. **Vaughan**. Well, as you may be aware, some of the regions are further along than others in the compacting process. Probably the region that is the furthest behind, if you will please, is the Northeast region where they can't seem to get very much consensus on which States are going to join with whom or where they're going to locate a site.

The States or the regions that are furthest along are in the Southeast, where they would initially use the facility in South Carolina; the Northwest, where they would initially use the facility at Hanford; and then the Rocky Mountain States, where they would initially use the existing facility in Nevada.

Senator **Ford**. For the record, can you advise me of the status of the Maxey Flats site in Kentucky?

Mr. **Vaughan**. Yes. I will be glad to. As you know, the site is closed, but we'll be glad to provide you for the record whatever information you'd like about the status of the site.

Senator **Ford**. You don't have any particular status of it?

Mr. **Vaughan**. I don't have, other than it's no longer being used, and there are no plans from the Department of Energy's point of view to reopen it or to advocate its being reopened.

Senator **Ford**. Mr. Chairman, I'll submit some questions for Secretary Vaughan for that particular item.

Mr. Vaughan, your testimony details recent major decisions of DOE, both already made and those to be made shortly. However, the proposal to close one of the gaseous diffusion plants is not touched on.

What is the status of this decision which is due in a month?

Mr. **Vaughan**. The decisionmaking process is in progress now. We have to evaluate the best way to optimize the use of our existing capacity, and we are evaluating whether to continue to operate all three plants, to place one in standby, or possibly to close one of the three. We would expect to complete that decisionmaking process within the next month and to share it with Congress——

Senator **Ford**. Are you saying to me and to this committee, Mr. Vaughan, that a decision has not now been made?

Mr. **Vaughan**. A decision has not yet been made.

Senator **Ford**. Well, that's very strange. We have a Congressman who's bouncing all over the territory, saying it already has been. He's got the information directly from high-level DOE, and certain plants are not going to be closed. And I just want to get it on the record.

Mr. **Vaughan**. Mr. Ford, I am aware that Congressmen from both the State of Ohio and from the State of Kentucky have issued those press releases. They're premature. We are gathering all the facts. We'll be reviewing those with the Secretary throughout the rest of this month, and we have not yet made a decision.

Senator **Ford**. Well, I'm glad to have that on the record, Mr. Secretary. It's a little embarrassing when they start announcing from high sources. It reminds me of a newspaper reporter when he gets his from a high administrative source who doesn't want to reveal his name for the fact he might be fired if he did, you know.

Senator DOMENICI. Who would get fired? The newspaper man or the leak?

Senator FORD. The leaker.

Senator DOMENICI. Oh.

Senator FORD. Oh, you're not going to fire the newspaperman. That's the way he gets his story.

Mr. VAUGHAN. I also presume you wouldn't fire the Congressman for attempting to appease his constituents either.

Senator FORD. But if he's telling the truth; that's all I want, you know.

Let me ask you one other question, and then I want to get to Mr. Rusche. How do you prefer your name be pronounced? Any way a Senator wants to? [Laughter.]

Mr. RUSCHE. Exactly.

Senator FORD. I like him. I'm getting ready to go with Chic, because Chic's on his side. Is that right?

Senator HECHT. Whatever you say, sir.

Senator FORD. Mr. Vaughan, the Senate administration deficit reduction plan adopted by the Senate last week contains an assumption that there is "reform" of the Uranium Enrichment Program. And according to the only documentation of this reform I have seen, the Department of Energy Uranium Enrichment Program's deficit reduction contribution would be $110 million in 1986, $202 million in fiscal year 1987, and $264 million in fiscal year 1988, or a total of $576 million for the 3 years.

This proposal was developed in the administration. Were you involved in developing the proposed reform?

Mr. VAUGHAN. Senator, we in the Department have committed to begin paybacks to the Treasury for past debts. We had not devised a specific payback schedule, but had indicated we would address that along with the other key uranium enrichment decisions to be made within the next month.

The particular numbers that are in the Senate proposal, I believe, were worked out between OMB and the Senate Budget Committee. Obviously if that becomes a part of the law, we will do our part to comply with it.

Senator FORD. Are you familiar with the cutbacks over the 3-year period?

Mr. VAUGHAN. We are aware of the numbers that you just cited to me.

Senator FORD. How would this reform work then in your mind if we cut back over the next 3 years $576 million? I'm concerned. We talk about wanting to get advancement here and do research and development and other things, and yet almost $600 million is reduced.

Mr. VAUGHAN. I'd like to let Mr. Longenecker respond to the details.

Senator FORD. Mr. Longenecker.

Mr. LONGENECKER. Senator Ford, any amounts that are repaid to the Treasury will result from cutbacks in our production, research and development or plant construction programs. We have been working over the last 18 months to carefully assess what the demand for enriched uranium is over the next two decades from all of our customers, both the foreign and domestic commercial customers, as well as military demand which we meet.

In the decisions that will be announced in a few weeks, we are devising a production strategy, a research and development strategy, and an investment strategy in new production capacity to meet that demand at minimum cost. We have not yet allocated those budget reductions or determined how the reductions in each of those categories would be taken.

We will provide the payback by cutting back in each of the areas to the extent necessary to meet the budget targets.

Senator FORD. You're going to cut back in each of the areas? Now, give me those areas again. You don't have to name them. Just give me the areas.

Mr. LONGENECKER. They are production costs, which are for the three GDP's: Operation and power. There is research and development which covers the R&D we're doing now on the advanced gas centrifuge and the AVLIS processes, and there is investment in new plant capacity which at this time is the gas centrifuge enrichment project in Portsmouth.

Senator FORD. Now, this would not increase the price of the SWU?

Mr. LONGENECKER. No, sir. It is our intent to continue to keep our price in the competitive range and to accommodate the payback through cuts in our budget.

Senator FORD. Of course, it all bothers all of us, but Mr. Rusche, let me ask you this. Would defense wastes go to the MRS?

Mr. RUSCHE. We've not made a final determination. It may turn out that from a transportation logistics standpoint, that it would be economic for it to pass through the MRS. Today, my judgment is that it probably will not, since the material will be prepared, ready for overpack, at the Defense Waste Processing Facility, DWPF, for example, at Savannah River as the first defense waste that will be suitable for placing in the repository.

But I'd not like to make a final choice until we've done all the studies on transportation logistics.

Senator FORD. If it should go in the final decision to MRS, would the safety standard for the transportation of the defense material be the same as that of the private sector?

Mr. RUSCHE. Yes, sir. If the waste is shipped by the defense program activities, such as defense activities now do, there is an equivalence between defense safety requirements and civilian safety requirements. If it were done as a part of the program, particularly if it were to go to MRS, it's clear that it would be done by the same transportation system that is handling the civilian waste and would be entirely equivalent in that regard.

From a safety standpoint, they ought to be equivalent in either case.

Senator FORD. Would there be the same notification to local officials and all that?

Mr. RUSCHE. Yes, sir.

Senator FORD. Maybe I missed it somewhere earlier, but why has there been such an escalation in the cost of the repository side of the programs? For example, estimated cost of site characterization used to be a few tens of millions per site; now it's around $750 million. Can you give me a reason?

Mr. RUSCHE. The best answer to that is that earlier estimates that you refer to were made at the time when people didn't know what they were talking about. [Laughter.]

Senator FORD. Well, do you now?

Mr. RUSCHE. I believe we do.

Senator FORD. Well, I am willing to pay for it if you're right.

Mr. RUSCHE. Well, I'm prepared to offer it as being right because I believe it is.

Senator FORD. OK, that's fine. I like your confidence.

Mr. Chairman, I may have a few more questions that I would like to submit in writing to these two gentlemen. I thank them for their testimony and I think it's been excellent today.

Senator DOMENICI. And will you answer the questions as quickly as you can? I know you're very busy, but we'll submit some also, and I'm sure the subcommittee will submit some.

Senator FORD. Mr. Chairman, would you clear up something for me for the record? I've got this report. And it shows that Uranium Enrichment Program is $4.5 billion in debt to the Treasury, and I understood you had it over $5 billion.

Senator DOMENICI. I have $5.723 billion.

Senator FORD. This says $4.5 billion. It's only a billion, you know.

Senator DOMENICI. Let's face it. They owe a lot of money and we ought to start collecting.

Senator FORD. I understand that, but if they don't need a billion, they sure as the world can use it from what I hear out here.

Senator DOMENICI. Well, we'll submit this and we'll just permit the Department, if there is something different, to submit their evaluation so that we'll have it in the record.

Mr. LONGENECKER. Thank you, Senator. Our submission that we made to your staff and made earlier to the Budget Committee indicates that the total net appropriation since we began civilian enriching in 1969 is on the order of $1.5 billion. The difference between the numbers depends on the handling of imputed interest and whether you include the funds that were appropriated for military purposes versus civilian. Those factors account for the differences between the various figures.

Senator DOMENICI. I'm going to yield to Senator Hecht. I'm sure he has questions—and Senator McClure. But before I do that, I do want to indicate to both Secretary Vaughan and you, Mr. Rusche, that I concur in what has been said previously about the way you are handling the problem, and particularly that of the nuclear waste.

As a Senator I heard, and I think Senator McClure will confirm that, over the years that there was no justification for ever having a lame duck session. I think our former leader used to say it's calculated to produce nothing but more problems, but I can say that there was one lame duck session that in my opinion will go down in history, and it was the one that produced the permanent Nuclear Waste Policy Act. We also passed the gasoline tax, as I recall, and some other things. But I'm not so sure we ever would have got one but for that lame duck session.

So for those of us who will be here for a while, we can always remind the people around here that it did one thing. It produced that Act. And Senator McClure was vital to it and Senator Johnston. They were the lead people.

And I think having you run it now as you are, we'll get some results. Without it, I agree with Senator Johnston, we have a very difficult time with nuclear energy if that doesn't work, and I'm hopeful we didn't make it too complicated. It's plenty complicated.

Mr. RUSCHE. May I add one comment?

Senator DOMENICI. Of course.

Mr. RUSCHE. Not only to thank you for the act, but to compliment the framers of the act even in those late hours in the evening or the early morning, or whatever they were, and that now having lived with it for just about a year, I can see all sorts of things that one might do different, maybe some would say better, but I'm convinced that if we fool with that act, if anybody opens the act, we're going to lose the ballgame.

So if I might make an impassioned plea, let us make it work, because I believe any improvements we make have the potential of making it much, much worse or less workable.

I appreciate it.

Senator DOMENICI. I have a question later where I'm going to suggest that we need to make a change, and I'd make the same comment; I'd rather change some other act rather than that one in order to get to one of the problems.

Senator Hecht.

Senator HECHT. Thank you, Mr. Chairman.

Senator Ford, when you mentioned before we're on the same team, I didn't answer you affirmatively enough. Yes, because these gentlemen, especially Mr. Rusche, is trying to do something with the stuff, and the tremendous amount of opposition—I don't think any Senator understands it anymore than I do, because in my State it's a very controversial issue, but at least they're not putting their head in the sand; they're taking steps, and they are making some important decisions on what to do with it.

On that basis, where is most of the defense nuclear waste now? Where is it being stored?

Mr. RUSCHE. Senator, most of the waste is stored at three sites: one at Savannah River, one at Idaho, and one in Washington State.

Senator HECHT. And how are you doing it? In the ponds, or what?

Mr. RUSCHE. No. At all of the sites, it's stored first as a liquid followed by reprocessing. At Savannah River, it is now being volume reduced, and in the latter part of this decade will begin to be vitrified in the first major vitrification effort in the country.

In Idaho, it is now first a liquid and then calcined and now stored as a dry calcine material in bins. In Washington State, it's still stored primarily in waste tanks as a liquid or liquid-salt-sludge mixture.

Senator HECHT. Roughly, repeat again, on these three sites what's the timeframe of safety in your opinion?

Mr. RUSCHE. The timeframe of what? Safety?

Senator HECHT. Safety. Uh-huh.

Mr. RUSCHE. I think most people would agree that as long as it's watched over carefully, it can be stored for an indefinite period by these various means, but it requires very active management. It's not the sort of thing you can go off and leave.

And to that end, the Department, through the defense waste management system, has put in place specific plans. The Congress has authorized the defense waste processing facility at Savannah River, a major facility which will be the first U.S. vitrification effort on a large scale. We have some small-scale test efforts, for example, at West Valley. But that will be the first one in the United States.

In Idaho, the material already is put in calcine form, and therefore is much less mobile, so long as it is maintained dry. It can be kept in that manner so long as one cares to watch it.

The situation at Hanford is a bit more active and requires very close attention. We are involved with it to some extent because of the interface physically between the potential civilian activity at BWIP and the defense activities in the nearby 200-acre area.

But I think the simple answer is that as long as we watch it carefully and spend the money that's required, it can be done safely. That's not the right long-term solution, though.

Senator HECHT. OK.

Mr. Vaughan, you won't be able to give me an accurate answer, but off the top of your head, last week when we passed the Senate budget measure and we cut down defense, what effect is this going to have on SP-100 and SPI?

Mr. VAUGHAN. The action that you took on the defense budget in terms of the support for SP-100 in the Department of Energy's budget will not be affected by that action since that's under the authorization which we are talking about here today.

There is a contribution of $17.5 million by SDIO in their budget for fiscal year 1986 and a continuing plan to share the funding in that program. General Abrahamson has assured me that he is committed to this effort to make sure we do have the energy sources for the housekeeping for these devices.

And I believe, although it's not directly under my control, that whatever the cuts were in SDI will not affect that program.

Senator HECHT. Down the line a few years, there's still no effect in your opinion?

Mr. VAUGHAN. I would believe that both the Department and SDI support SP-100. I think that's a commitment. We will have to have some good results from the effort planned in the coming year, which is analyzing it, focusing on a series of missions which will help pinpoint the potential for more specific applications for that energy source.

Senator HECHT. I haven't been here as long as my colleagues, but as long as you have commitments, if Congress doesn't fund them, what good are these commitments?

Mr. VAUGHAN. Not very much.

Senator HECHT. Thank you.

Let me ask if I heard you correctly on your statement as far as the SP-100. You want to use existing facilities if that is possible. Is that correct?

Mr. VAUGHAN. Yes.

Senator HECHT. I just wanted to reemphasize that for the record.

Mr. VAUGHAN. Some will need to be modified, but we're not talking about building new facilities from scratch. And that applies to all five of the sites. That's the basis on which they've all proposed.

Senator HECHT. Mr. Rusche, I note in your testimony on page 22 that DOE's waste program plans to allocate $42 million in fiscal year 1986 toward regulatory and institutional activities which includes funding for affected States so they can study, determine, comment on environmental and social issues relating to nuclear waste. In 1985 DOE only approved a $2 million grant for Nevada to conduct these activities, and the State is now taking DOE to court over its failure to approve a larger funding request.

Would you elaborate on this funding issue, identifying those State activities that you believe are appropriate or inappropriate for funding by DOE?

Mr. RUSCHE. Senator, may I comment first on the $42 million? The $42 million for 1986 provides——

Senator HECHT. Million.

Mr. RUSCHE. Million.

Senator HECHT. Yeah, you said billion.

Mr. RUSCHE. I'm sorry. Million, with an M—provides not only grant funding for the States and affected Indian tribes, but also for the interagency work that we do with the U.S. Geological Survey, the Bureau of Mines, and other institutional work.

We have lumped all of those costs under that general category. So the size of that number compared with 2 million should not be misinterpreted, misread to mean that there's a much larger amount that appears.

Now, with respect to what the funds are used for by an individual State, we have explicit funding guidelines which each of our operations offices uses as a basis for evaluating such grants, and I think that on the specific point with your State, my attorneys would probably urge me to not address the issue in this forum since your State has offered me the opportunity to address it in a more formal forum, namely in a lawsuit, but our guidelines which do exist provide, I think, an entirely appropriate basis. I do not have them before me, but I'd be glad to see that you have a copy of them if that would be useful, and even come by and talk to you about them.

I think they provide pretty clear guidance as to what can and can't be done.

Senator HECHT. You know, the lawsuit does not mean that everyone in the State is in favor of the lawsuit.

Mr. RUSCHE. I appreciate your comment, sir.

Senator HECHT. Also, will the States be receiving significantly more money for these activities once site characterization begins?

Mr. RUSCHE. I would imagine so, in that I expect the level of activity, certainly a level of activity by DOE, and I'm sure the States, likewise, would increase, and we'll be receptive to all appropriate activities to see that the State is fully involved.

Senator HECHT. What is the total amount of money which you're going to spend for the three sites to determine the feasibility?

Mr. RUSCHE. I believe the total amount is a little over $2 billion. I don't have the exact numbers.

Senator **Hecht**. In round figures, $2 billion?

Mr. **Rusche**. Between $2 and $2½ billion. I think the average is about $750 to $900 million, ranging from about $600 to nearly $1 billion. So around $2 to $2½ billion.

Senator **Hecht**. Is that pretty equally divided between all three States?

Mr. **Rusche**. No, sir. The different medium—the costs vary between the media. For example, they're different in salt than they would be in basalt or in tuff.

Senator **Hecht**. Roughly, do you have those figures off the top of your head?

Mr. **Rusche**. I think they range from about $600 million in tuff to $900 million in basalt.

Senator **Hecht**. And how would you characterize those three sites?

Mr. **Rusche**. Sir?

Senator **Hecht**. Characterize the three sites for me, please.

Mr. **Rusche**. I'm not sure what terms I can use.

Senator **Hecht**. I mean how would that identify to Washington, Nevada?

Mr. **Rusche**. Oh, I'm sorry. The tuff is the geologic medium in Nevada. Basalt is the geologic medium in Washington State. And salt is the medium in the now-proposed Texas site.

Senator **Hecht**. I see. And give me those figures again, now that we've identified——

Mr. **Rusche**. I think they're about 6, 750, and 9—$600 million, $750 million, and $900 million.

Senator **Hecht**. Thank you. I have no further questions, Mr. Chairman.

Senator **Domenici**. Thank you, Senator.

Senator McClure.

The **Chairman**. Thank you, Mr. Chairman.

Senator **Domenici**. Secretary Vaughan, did you have something?

Mr. **Vaughan**. Senator Hecht, I might add, if it would be of interest to you, I do have a recent letter here from General Abrahamson expressing his support for the SP-100 program, and I would be pleased to enter that in the record if you'd like for me to do so.

Senator **Hecht**. Please do, and I would like to have a copy of it myself if I could.

They're going to analyze and look at all of the sites; they're going to determine the site which is most feasible and has the facility. That's just what they said.

Senator **Domenici**. Is that what the general says also?

Mr. **Vaughan**. The general doesn't comment on site selection. He's leaving that up to us.

Senator **Domenici**. You can put it in the record. [Laughter.]

[The information referred to follows:]

OFFICE OF THE SECRETARY OF DEFENSE,
Washington, DC, April 25, 1985.

Mr. JAMES W. VAUGHAN,
Acting Assistant Secretary for Nuclear Energy,
Department of Energy, Washington, DC.

DEAR MR. VAUGHAN: I wish to reaffirm my strong desire for continued DOE support for the SP-100 space reactor project. Development of this system constitutes enabling technology for many SDIO missions, and its use is an integral part of our planning for space-based capabilities. In addition to satisfying the SDIO need for continuous high-level space power, this technology provides a steppping stone to our multimegawatt power needs. The Space Power Project within SDIO includes integrated SP-100/multimegawatt feasibility investigations. It would be of great benefit to the SDIO program if the feasibility of the SP-100 technologies can be demonstrated at the earliest date consistent with sound technical judgment and programmatic constraints.

I intend to press for full funding of our FY-86 budget allocation for the SDIO portion of the SP-100 program. The technical and financial contributions of DOE to this joint effort are vital to its success, and I am extremely pleased that your organization is such an active supporter and participant. Under DOE's charter to develop advanced nuclear technology, the inclusion of space reactor power systems in your overall program is of great value to SDIO and other defense agencies.

Sincerely,

James A. Abrahamson,
Lieutenant General, USAF, Director, Strategic Defense Initiative Organization.

Mr. Rusche. Mr. Chairman, the top of my head wasn't quite as good as I thought. Could I slightly improve the precision of those numbers?

For tuff in Nevada, $630 million estimated.

Senator Hecht. I'm going to write that down.

Yes?

Mr. Rusche. For basalt in Washington, $695 million.

For salt in Texas, as they are now proposed, $870 million. And that comes out to be about $2.2 billion altogether: $2.3, or something like that.

Senator Ford $750 million average.

Mr. Rusche. That was the number I remembered.

Senator Domenici. Senator McClure.

The Chairman. Thank you, Mr. Chairman.

First let me compliment the witnesses on their presentations this afternoon, and particularly to comment on the performance of Mr. Rusche in the very difficult job that's been handed to him in trying to administer a program that must be one of the most difficult balancing acts of public versus nonpublic interests and various shades of public interests. It's a fantastically difficult job, and I think the fact that it's moving forward at all is a tribute to the skill with which it's being administered, and I want to state that publicly——

Mr. Rusche. Thank you, sir.

The Chairman [continuing]. And to compliment Mr. Rusche on the job that is being done.

I am concerned about what we are doing in breeder reactor R&D. I know others have mentioned it in general terms and in specific terms. But virutally all the cuts in fission R&D are taken from the breeder budget. This budget's already down 16 percent compared to fiscal year 1984, and now we're faced with another 15-percent reduction in the fiscal year 1986 request.

I guess if we intend to keep our major facilities not only operating but also doing meaningful research in the area of technology development, we'd have to question whether the fiscal year 1986 request is adequate to accomplish that goal.

Let me ask three or four questions along that line. Considering this country's concern about nonproliferation, especially as it relates to the breeder fuel cycle, why isn't the Department placing more emphasis on the metal-fueled integral fast reactor concept?

Mr. VAUGHAN. Senator, I'm aware that the metal fuels, or the so-called Argonne IFR, concept has been touted as having nonproliferation advantages because, as advertised, much of the work could be done on a single site.

That, however, is a two-edged sword, because it also increases the total number of sites—if those reactors were deployed at which attractive material might be available for diversion. Even the peer review committee appointed at our request by the University of Chicago to review that subject has raised a number of questions as to whether the nonproliferation advantages are as great as touted.

And so I think we need to wait to see how that review comes out.

The CHAIRMAN. Mr. Vaughan, isn't the proliferation question with respect to this kind of processing of the fuels related to the separation of the plutonium from the spent fuel and the availability of that plutonium?

Mr. VAUGHAN. Well, in the case of the IFR——

The CHAIRMAN. I mean in general, not just the IFR. The general question.

Mr. VAUGHAN. I'm sorry, because you had initially referred to the so-called metal fuels which do use a slightly different process and wherein——

The CHAIRMAN. But isn't the problem with respect to the fact that there is plutonium which, if separated, could become weapons-based?

Mr. VAUGHAN. That is the concern; yes.

The CHAIRMAN. That is the concern in nonproliferation?

Mr. VAUGHAN. That is the principal concern; yes.

The CHAIRMAN. If then there is a process by which that plutonium is never separated, doesn't that lend itself to nonproliferation goals?

Mr. VAUGHAN. Even in the process of taking the spent fuel and in reprocessing it on site by converting it back into a new fuel rod, which is what is advertised for the so-called IFR reactor, you do have material that is in an attractive form if——

The CHAIRMAN. Attractive form for what? For weapons?

Mr. VAUGHAN. If people wanted to divert it, they could do more things with it than oxide fuel. It's not in a readily available form as separated plutonium. And so in that sense, it's less attractive.

The CHAIRMAN. Is it more attractive than the spent fuel rod itself? [Pause.]

What is more attractive to the fuel in that form than it is in the form of the spent fuel rod itself?

Mr. VAUGHAN. Well, in the metal fuels, it's easier to separate and get the plutonium than it is in the oxide fuel form.

The CHAIRMAN. Well, that's kind of a surprising statement to me. It doesn't comport with what I've been told, but it may be accurate. But plutonium is never separated out.

One of the things that we've been talking about in the reprocessing is separation of plutonium and the recombining of fuel rods in forms that are not susceptible to the proliferation threat. Isn't that the thrust of what we've been talking about in reprocessing in the nonproliferation area?

Mr. VAUGHAN. That is one of the thrusts.

The CHAIRMAN. And here is a process that never separates the plutonium, leaves it in combination that is not at all suitable for weapons production. And it seems to me that it answers a number of the nonproliferation goals.

Mr. VAUGHAN. It does answer some of those, but if people wanted to divert that material in that form, then the plutonium could be separated, and you have increased the number of sites where it's available to be——

The CHAIRMAN. That's already true of the spent fuel rod. If they want to get plutonium and they get spent fuel rods, they can get the spent fuel rods and take the plutonium out.

Mr. VAUGHAN. But they have a much harder job doing that with oxide fuel than they do with the metal fuel rod.

The CHAIRMAN. I'm going to test that because that's the first time I've heard that statement made. I've heard the opposite statement made.

What are the Department's specific program plans for development of the IFR concept?

Mr. VAUGHAN. Senator, in fiscal year 1986 we were not able to include the money for the IFR effort at the level we had originally envisioned.

The CHAIRMAN. Within the——

Mr. VAUGHAN. Excuse me, if I may——

The CHAIRMAN. Surely.

Mr. VAUGHAN. We do have in test reactors at this time, some of the fuel rods for the IFR concept, the so-called ternary metal fuel rods undergoing some proof of principle tests, along with some proof of principle efforts for the reprocessing techniques which we've been discussing.

The CHAIRMAN. Now, there's some money then identified for some work in this area.

Mr. VAUGHAN. Yes. Some of that work will be ongoing.

The CHAIRMAN. Is that within the $17 million fuel cycle development program?

Mr. VAUGHAN. No, sir; it is not within——

The CHAIRMAN. Is there any of that $17 million fuel cycle development program—is there any money designated specifically for metal fuel reprocessing?

Mr. VAUGHAN. I don't think so. No, sir.

The CHAIRMAN. Within the Argonne facility's budget, what research is being planned in support of the IFR concept?

Mr. VAUGHAN. I'm going to let Dr. Wilcox respond.

Dr. WILCOX. This is primarily the technologies of the fabrication of the rods, inserting those rods in EBR-II to test their performance and characteristics, and also inserting some of those rods in FFTF to test their general characteristics.

The CHAIRMAN. Do you know how much money is involved in that activity?

Dr. WILCOX. Not exactly.

The CHAIRMAN. If you could provide that for the record, that would be satisfactory.

Dr. WILCOX. Yes, sir. I will.

[The information follows:]

In 1984, we undertook a feasibility test program for the Integral Fast Reactor (IFR). That program was for a 2-year period. That program included core design, fuels and materials testing, and reprocessing technology investigations. A key aspect of that program was whether or not the fuel would perform in a way different and better than metal fuels performed in the 1960's. Fuel performance tests, as the University of Chicago peer review report on the subject indicates, and essential to whether or not the IFR concept is feasible. Prototype fuel pins will be irradiated in the Fast Flux Test Facility and the Experimental Breeder Reactor-II reactors in FY 1986 and FY 1987. The remaining technology programs recommended by Argonne will be deferred. Funding in FY 1985 for evaluation of IFR feasibility is $10 million; the DOE FY 1986 budget contains no explicit funds for the IFR, but in-core tests in FY 1986 are covered in the 1986 budget request.

The CHAIRMAN. Successful deployment and improved performance of our current generation of light-water reactors is an area in which both DOE and EPRI have a legitimate and important role. The DOE lab facilities have considerable expertise in areas of safety research, quality assurance, and source term research.

Does DOE plan to enlarge its role in these areas in order to tap the resources available at the labs to their fullest potential?

Mr. VAUGHAN. Yes, sir; we are, within the budget constraints we have, looking at expanding our efforts in that regard. We've recently tried to do some catalyzing efforts to work closely with EPRI, with the so-called IDCOR organization, and with NRC to see if we can't better utilize our capabilities in Idaho, Argonne, and others to help bring this source term and severe accident question to a head, so we can take advantage of the data that we think is there that will help in emergency planning and other factors.

The CHAIRMAN. I am concerned about whether or not the proper focus and coordination can be given to these programs which I think are vital to us. Are these program elements managed under a separate Deputy Assistant Secretary?

Mr. VAUGHAN. No, sir. Those efforts are currently part of the effort being coordinated with all of our civilian reactor development efforts.

The CHAIRMAN. The fiscal year 1986 budget includes slightly over $100 million for advanced converter reactor technology. Research here primarily centers around conceptual design work on advanced LWR's and on modular, passively safe, high-temperature gas reactors and liquid metal-cooled reactors.

While that's certainly worthwhile in pursuit of a second generation nuclear area, none of the designs will ever reach the marketplace until the safety, economics, reliability, and licensibility of the reactor has been fully demonstrated in a test program.

Has the Department done any thinking about how such testing might be accomplished?

Mr. VAUGHAN. We have begun some preliminary thinking in that regard. You were not here when I gave my opening statement, but I did indicate orally that it is our intent to, as we present a program a year from now, and to be in a position to do that within the next year, to narrow some of those choices so we can pick the best alternative, or maybe two, based on their economic and technical merits in order to lead to focusing something that we can in fact demonstrate.

And that demonstration will need to be determined based on whether it will be a so-called demonstration of licensing capability by test facility, or perhaps a broader plant that the private sector would be willing to invest in with confidence.

The CHAIRMAN. Let me look at that from the other end of the process, looking back from that time toward the present. If you really intend to have participation with the utilities and the vendors—and I assume that that's where you would necessarily hope to get—then when you get to that point, you're going to have to have a program that is attractive to them that's going to have to meet their needs.

What is being done now to make certain that their needs are going to be met in the development of the proposal so that we don't get to the end of that process and find out something that we can't sell to them?

Mr. VAUGHAN. All of the innovative concept efforts that we're doing do involve close organization not only with EPRI, but also with the participating vendor organizations which interface on a regular basis with the utilities to assure that we have their needs and ideas in mind.

In any effort that we use to focus the total program toward a series of concepts, we would have to arrange and would intend to arrange to accomplish by a consensus review process that would include key people from all of those facets.

The CHAIRMAN. Is that concensus review process in place now, or something that you're going to develop?

Mr. VAUGHAN. I would say the key elements of it are already in place.

The CHAIRMAN. Have you had comments from them as to whether or not it is adequate or inadequate?

Mr. VAUGHAN. As to whether the process is adequate or inadequate, or the designs are adequate or inadequate?

The CHAIRMAN. No, the process.

Mr. VAUGHAN. OK. I have not solicited specific comments on the process per se because if I proceed to focus these efforts and narrow the choices, then I've got to have a slightly different process from the one that's underway, and it has been up, to this year, premature to do that.

The CHAIRMAN. I'm sure that's true, and yet if we are going to be able to get to the point of narrowing them, it seems to me that it's important that that process that you say the major elements of which are now in place, needs to be working well or you'll never be able to take the next step very constructively.

And it seems to me that if the industry, the utilities and the vendors, are satisfied with the process now, then you are more likely to be able to take the next step constructively. If they're not satisfied now, I would say that's a very great danger sign that you're going to run into trouble in taking the next step.

And that's the reason for the question, as to whether or not they are satisfied that the process is working well or structured so that it can work well.

Dr. WILCOX. Senator McClure.

The CHAIRMAN. Dr. Wilcox.

Dr. WILCOX. I think we're making an extraordinary attempt to make sure that utilities, through EPRI, and individually, through the vendors that are representing the advanced concepts and some of those that are not in that advanced concept design, are involved in almost all the stages of our planning. Within a week to 10 days some of the first letters will go out to those that are invited to participate directly in this process of evaluation and review of the designs.

We will be very sensitive to the views coming back there as to just where the yeses and noes and constructive comments lie. But the process does allow for a great deal of interaction and we're promoting a great deal of interaction there.

The CHAIRMAN. You're going to increase the efforts on the interaction as I understand it. Is that correct?

Dr. WILCOX. Yes, sir.

The CHAIRMAN. I think that's important that you do, and I know that you don't want to go out and drum up opposition to what you're doing or try to create criticism where there isn't widespread criticism now, but at the other side, I think we must be very careful we don't listen defensively against criticism, but listen rather openly to determine whether or not the process is working well from the people who are going to be involved in it and are involved in it.

Just a couple of other questions. We've been operating without an Assistant Secretary for Nuclear Energy since last October. When might we expect to see this position filled?

Mr. VAUGHAN. The Secretary is actively interviewing candidates and has stated publicly that he'd like to have somebody with some background from industry to come in and help us do the job.

I can't tell you exactly what his timetable is because it's a very critical search process, and he wants the right person.

The CHAIRMAN. I'm just glad my wife didn't wait for the perfect potential husband to come by. [Laughter.]

Senator FORD. I think I'll move back to the table on that. I may have to defend myself.

The CHAIRMAN. I just wonder really when that perfect candidate is going to come by.

Senator DOMENICI. Knowing your wife, she's so great——

The CHAIRMAN. She's fussy, too.

Senator DOMENICI. She might have waited a little while. [Laughter.]

The CHAIRMAN. I don't need that kind of help. It's lasted 35 years. I hope it'll last a little longer.

One final question in that general area. The Nuclear Regulatory Commission has more and more moved away from theoretical research even in safety, and more and more toward applied research; that is, research that's applied to specific problems before them at the time.

I think I'm correct in saying that. I think they would confess that it's true. It seems to me that some of the theoretical research in safety, that which goes beyond those activities by NRC, is nevertheless absolutely essential not only in the current generation of LWR's, but in advance concept LWR's, and absolutely essential if indeed we're going to be able to build any kind of a breeder program to have an active safety research program anticipating and moving ahead and refining the research activities of others.

So I, along with some others, have been pushing for an increase in the research components of the DOE budget to pick up where NRC activities stop, at the edge of theirs.

Do you agree with that generalized concept?

Mr. VAUGHAN. I do agree with your generalized concept. Obviously, the safety features are a key part of all of our advanced reactor work, including those efforts to achieve what is popularly being called more passive safety or more inherent safety.

We're doing as much as we can within the budget constraints. There clearly is more we could do, and I think it's a proper mission for DOE to undertake.

The CHAIRMAN. Well, I think it's absolutely essential to the future of this country, not just to the future of a particular energy or energy industry, that we know what it is we're doing and we create the opportunities for the development of those energy programs that will be applied in the 1990's and into the next century.

If we don't do the research now, we can't have those programs available to us 10 or 15 or 20 years from now. And it's absolutely fundamental to the security and the well-being of our people that we have adequate energy available to us in forms and costs which are acceptable in our society. I think we have lost a little bit of the momentum—no, I'll rephrase that. I think we've lost an awful lot of the momentum that we had at an earlier period of time when there was a perceived energy crisis.

And now that there is a perception that oil and gas are abundant and plentiful and will become cheaper over a period of time and they'll be available forever at constantly lowering cost, people are lulled into extremely false sense of security.

I think you would agree with that, too.

Mr. VAUGHAN. Senator, I could not agree with you more. I think we're all committed to trying to work to that objective.

The CHAIRMAN. I'm sure that's true, Mr. Vaughan, and I don't question that commitment on your part. But OMB is faced with today's problems today and they tend to focus more on short-term than they do on long-term. And I'm afraid when we retreat time and time again to the question in the current budgetary crisis, we tend to change all, nearly all of our options, to shade the options in favor of the short-term fix and against long-term management.

I just think it's extremely dangerous to do. I think it's an understandable human tendency. I do regard the people at OMB as human. [Laughter.]

And I'm just concerned that we're not emphasizing that long-term research enough.

Mr. VAUGHAN. We share your concern. The budget is constrained. And as I commented again in my opening statement before you came, it's important that we not only do what we can to restore the nuclear option in the near term, but that we have a continuum of research and development so that we don't mortgage our future.

The CHAIRMAN. And I know that requires balance, and I know there will be argument over what that balance should be, but I believe we've gotten to the point which for at least this Senator, tells me that we've succumbed to the short-term pressures at the expense of long-term options.

Mr. Rusche, the issue has been raised as to whether the utility payments to the Nuclear Waste Fund should be paid on a monthly basis rather than quarterly.

With respect to the one-time fee for spent fuel generated prior to the establishment of the Fund, some have suggested that commercial interest rates should be charged for any deferred payments rather than Treasury rates.

Would you care to comment on those two proposals?

Mr. RUSCHE. Yes, Senator. On the first, with respect to payments monthly versus payments quarterly, when the contract was being developed a couple of years ago, some consideration was given to that issue and a conclusion was reached on the basis of not an extensive analysis, but on I think fair consideration, that the practicality of the matter tended to focus attention on the quarterly payments.

I have since seen some data developed by the utilities themselves that make a couple points clear. And based on that data, I'm convinced that the earlier, perhaps more cursory analysis was better founded than I thought.

My bottom line conclusion is that I think there's no real advantage. I realize my friends in GAO have made some estimates which I believe are somewhat greater than the facts would support as practiced by the utilities as the amount of money that might be collected.

But the bottom line, the answer to this, and likewise to the second point, is that whatever interests are paid or earned go to the cost of supporting the program. And I think that there's not a question of making money where there's no money to be made. It's more a question of managing the money that is extracted from ratepayers, if I can put it in that form, in the most cost-effective way. And there's no question but that if you charge commercial rates rather than Treasury rates on money that's in hand, more interest would be earned.

The question is whether we did right in offering the incentive as we did, and I think the fact that people are going to pay on the one-time fee means that the incentive was done right.

On the deferred payments, I think the question comes much more to the practicality as to whether we earn the interest in the Government, or whether the payment is deferred, as it were, from the standpoint of the rate payer. Both steps could be taken. It's my view at the moment that neither one of them warrant the effort that we've got, plus they would require changes in the contracts which cannot be done unilaterally.

The CHAIRMAN. Thank you very much. And thank you, Mr. Chairman. I have some further questions that I'll submit for the record if I may for response in writing.

Senator DOMENICI. Thank you, Senator. They'll be submitted for answer.

I just have one question left. Let me, however, while we have these witnesses at the table, explore with Mr. White, Associate Director of Research, Community, and Economics Division for the GAO—Mr. White, where are you?

Let me—I know you've been patient. Senator Bingaman had basically requested that we ask you to come here. I understand that you have your prepared testimony, and we have submitted questions to you in writing.

Mr. WHITE. We are prepared to answer your questions. We were not asked to submit prepared testimony, but we have your questions.

Senator DOMENICI. Were you prepared to give the answers? Are the answers prepared in writing, Mr. White?

Mr. WHITE. We have them in writing. Yes, Mr. Chairman.

Senator DOMENICI. I wonder if you would accommodate us. I'm afraid we are going to run out of time. We have four public witnesses. Could we, as soon as this panel is finished, just ask you to submit the answers to the questions in writing, and then if the Senators need further interrogation, we would accommodate both them and you on another occasion?

Mr. WHITE. That would be fine.

Senator DOMENICI. I greatly appreciate it.

Mr. Vaughan, either for you or your enrichment expert, let me just ask this question. I think you are aware of the fact that in October of this year, I received assurance from the Secretary that the DOE would run its enrichment complex in the split-tailed mode; that is, adding uranium from the stockpile rather than using more electricity to squeeze more uranium out of the feedstock.

Now, there's been some question as to whether this commitment which I received and circulated and actually received and communicated back in writing, there is some confusion as to whether it has been kept.

Is there someone here who could describe the operation of this complex during the past 6 months?

Mr. LONGENECKER. Senator, we have complied with the agreement we made with you last fall to operate the total enrichment complex in a mode in which we would match the operating tails of the total complex to the average transaction tails of all of our customers.

That calculation and its explanation cannot be done in two sentences, but let me explain basically how we operate the complex today and how we are planning to operate for the rest of this fiscal year.

Senator DOMENICI. You don't have to do that. You can do that for the record.

Mr. LONGENECKER. All right. I'd be glad to.

Senator DOMENICI. Let me just take your answer. You are then saying that consistent with that understanding which had, I think, a legitimate basis and so did the Secretary, you are saying it has been complied with and will continue for the next 6 months.

Mr. LONGENECKER. Yes, sir. At this point in time, the average customer transaction tails assay is about 0.26 percent. Throughout this fiscal year, I anticipate that the average operating transaction tails assay of the three plants will be about 0.26 percent.

Senator DOMENICI. Would you then submit for the record a little more detail so that we can confirm that it meets our understanding, and we'll make it a part of the record.

How much time would you need to do that?

Mr. LONGENECKER. We can do that in a few days.

Senator DOMENICI. All right, fine. If we give you a week, that's adequate for all of us.

[The information referred to follows:]

Department of Energy
Washington, D.C. 20585

May 30, 1985

Honorable Pete V. Domenici
United States Senate
Washington, D.C. 20510

Dear Senator Domenici:

This is in response to your question at the May 13, 1985, hearing regarding the Department of Energy's operational plans for the gaseous diffusion plants during FY 1985. Let me assure you that the Department does not plan to operate its uranium enrichment plants in a split tails mode during FY 1985.

Based on customer elections of the Variable Tails Assay Option under existing contracts, we project that the average transaction tails assay for FY 1985 will be about 0.26 percent U-235. The average operating tails assay over the year will also be approximately 0.26 percent U-235. A higher tails assay is good for the mining and milling industry since it uses uranium inventories and/or creates sales opportunities for the industry.

Of course, instantaneous operating tails assays at each of the three gaseous diffusion plants may be different throughout the year than the average tails assay. For example, on March 1, 1985, the operational tails assay was 0.25 percent U-235 at Portsmouth, 0.30 percent U-235 at Paducah, and 0.56 percent U-235 at Oak Ridge. At that time, Portsmouth was operating at 61 percent of design capacity, Paducah at 29 percent, and Oak Ridge at 25 percent. However, starting April 1, 1985, the operational tails assay at Paducah was reduced to 0.25 percent U-235.

Because of the relatively small amounts of electric power being used at the Oak Ridge plant, the uranium flows inside of the process equipment must be increased so that the plant can be controlled safely. Increased flow rates can only be accomplished by increasing the tails assay at the plant. However, Oak Ridge tails material, which exceeds the average transaction tails assay, is being fed to the Paducah plant where the assay of the material is reduced further. The effect of this is the same as though Oak Ridge was operating at the Paducah tails assay.

Regarding the Paducah plant, due to the low power level at the plant during the early part of this fiscal year, a tails assay of 0.30 percent assay was selected to optimize the separative work output of the plant. With the use at the Paducah plant of Experimental Test Energy from the Tennessee Valley Authority and of unfirm power from the Electric Energy, Inc., sponsoring utilities, the tails assay has been reduced to 0.25 percent U-235 while still maintaining optimum separative work production. Moreover, when the material from Paducah is averaged over the whole year with the 0.25 percent U-235 tails material from Portsmouth, where over 50 percent of the total year's production will occur, the resultant complex tails assay will be essentially the same as the transaction tails assay.

Please let me know if I can provide you with any more information.

Sincerely,

James W Vaughan, Jr

James W. Vaughan, Jr.
Acting Assistant Secretary
for Nuclear Energy

Senator DOMENICI. Any further questions?

We have three or four we'll submit in writing, and answer them as soon as you can.

Thank you very much. You've been most cooperative. It's been a good hearing.

[Pause.]

Senator DOMENICI. We have Dr. Kerry Dance, president of GA Technologies, San Diego. Is Dr. Dance here? Come and take your place up here at the table. Mr. Edward Farley, Jr., chairman of the board and president of Atlas Corp.; Mr. Vincent Boyer, chairman, Gas-Cooled Reactors Associates; Mr. Sol Burstein, vice chairman of the board of Wisconsin Electric Power, on behalf of the American Commonwealth on Radwaste Disposal and other entities.

All right, if I could have a bit of order for the record now. We have questions which were submitted to GAO for this hearing. The questions and answers in writing will be made a part of the record.

Unless there is some reason that we should not proceed in the order that I called the witnesses, we will do it in that way. Dr. Dance, president of GA Technologies, you may proceed first, and then Mr. Edward Farley, Jr., you're next.

Dr. Dance.

STATEMENT OF DR. KERRY D. DANCE, PRESIDENT, GA TECHNOLOGIES, INC.

Dr. DANCE. Thank you, Mr. Chairman and members. I am Kerry Dance, presdident of GA Technologies, and I appreciate the opportunity to testify before the committee and report on the progress made during the past year.

Senator DOMENICI. You'll have to put the mike up a little closer.

Dr. DANCE. The support and guidance of this committee has been crucial to this progress. As you know, GA has been the center of gas-cooled reactor research in the United States for a quarter of a century. This has resulted from a private investment of over $500 million, as well as our role as principal contractor to DOE for HTGR development.

Unfortunately, nuclear power in genreal, whether it be gas reactor, water reactor, or liquid-cooled reactor, has been stalled for nearly a decade. I personally doubt that any part of the nuclear industry can be revived without a change in public attitudes and a redoing of our nuclear infrastucture.

I doubt that this can be accomplished without the ability to think new thoughts and to try new approaches.

Many in the industry feel otherwise. They feel that we can revive the industry without new concepts or major restructuring. I wish them success, but I think that the evidence of the past 10 years suggests otherwise. I know that the question is at least in doubt.

I also know that nuclear power will be needed again in this country and that the cost of losing a domestic nuclear industry will be very, very high. We at GA therefore feel very strongly that a complementary program to the present LWR efforts which offers a new concept is crucial.

The modular inherently safe HTGR program is such a concept. We at GA are not alone in this belief, as evidenced by the participation in the program of Combustion Engineering, General Electric, Bechtel, Stone & Webster, Oak Ridge National Laboratories, and of course Gas-Cooled Reactor Associates, which represents a significant fraction of the nuclear utilities in this country.

The purpose of the present modular HTGR program to which I am referring is to reach agreement and begin design on a small, completely passively safe, modular factory-fabricated reactor. Such a design would remain completely safe to the public at all times, even with no operator action or active cooling systems. No emergency evacuation planning would be needed.

These features could do much to indicate to the public that we in the nuclear industry really have something new and better. A small, passively safe HTGR could also give assurance to the utility owner that he would not lose his investment as happened at TMI, and the small size would make the raising of capital much easier.

Such a reactor could be largely factory-fabricated and could run on line in 4 to 5 years, making the planning and capacity additions immensely easier.

In short, a successful modular HTGR could do much to break the institutional barriers which have stopped nuclear in this country.

But any new concept must be real. And I think as you've discussed here today, it must be shown to be real to the public. Therefore, we strongly urge that the program dollars be focused on a single goal, the building of a licensing and technology test reactor. This could most readily be done on a Government site with broad participation of qualified groups.

Such a project could provide the hardware and licensing reality needed for the industry to begin, and could be tested in accident extremes to assure the public of absolute safety. We must move now if any of these efforts are to be meaningful in preserving the nuclear option. We are running out of time.

At the same time, we do recognize the budget constraints, the budget realities, and we recommend that the fiscal year 1986 budget be frozen at the fiscal year 1985 level of $36 million. Normally, to proceed on a project, we would have to recommend a budget increase. But we recognize the need for spending restraint, and we feel that many traditional parts of the HTGR program must be dropped to allow the modular program to go forward.

It will be tight, but real progress on a licensing and technology test project can be made with a budget freeze. However, we feel that a 30-percent cut in the HTGR budget, which is already only a very small part of the fission budget, to the administration's request level of $26 million will definitely slow progress.

We look forward to the continuing support and direction of this committee, and feel that we are on the threshold of a project which could be the key to reviving a major energy option.

Thank you.

[The prepared statement of Dr. Dance follows:]

TESTIMONY BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

FY 1986 DOE AUTHORIZATION
HIGH TEMPERATURE GAS-COOLED REACTOR PROGRAM

KERRY D. DANCE
PRESIDENT

GA TECHNOLOGIES INC.

May 13, 1985

Mr. Chairman, I am Kerry D. Dance, President, GA Technologies Inc. and I appreciate your providing me this opportunity to testify before your Committee. In view of the long term support and guidance of this Committee, I am particularly pleased to report to you on the significant progress made during the past year on the High Temperature Gas-Cooled Reactor program and to offer our recommendations on funding and future program direction.

We were gratified this past year by the actions of the Department of Energy in refocussing the HTGR program to respond to the Congressional guidance and the changing user and industry needs. We are also pleased by the continued support by the Department and the Administration for the program as indicated by the inclusion of the HTGR as a part of the FY'86 fission budget.

The vitality and progress of the program this past year is reflective of the cooperation and contribution made to the HTGR program by all of the major program participants, including Combustion Engineering, General Electric, the Bechtel Group, Stone and Webster Engineering Corporation and Oak Ridge National Laboratory. In particular, I would like to cite the role and contribution of Gas Cooled Reactor Associates (GCRA), the utility/user organization which provides to the program the current perspective and requirements of the ultimate user of HTGR systems and, in addition, performs for the Department of Energy the overall program coordination function. Their efforts have been most important in bringing together and developing a consensus among the program participants on the key elements of the program.

GA, which has been the center of gas cooled reactor technology and commercial activity in the United States, continues as a principal contractor on the Department of Energy's HTGR design and development program. We continue to be enthusiastic about the technical merits of HTGR's and over the prospects for the concept to make a major contribution to our future national energy picture. We look forward to the opportunity of applying our unique HTGR technical capability and experience (much of which resulted from our private investment of over $500 million) built up through our participation in essentially all facets of the U.S. gas cooled reactor program from inception. This is augmented by our involvement in international gas reactor programs through ownership, license, technical exchange agreements or contract activities.

Of particular significance to the HTGR program at this time is our long standing relationship with Hochtemperatur Reaktorbau (HRB) in the Federal Republic of Germany. GA is a 45% owner of HRB with Brown Boveri & Cie, the owner of the other 55% share. HRB was the designer and a participant in the construction consortium for both pebble bed high temperature gas cooled reactor plants which have been installed in Germany - the AVR and THTR plants. GA also maintains a cross-license agreement with NUKEM, the German HTGR fuel technology and fabrication company. These relationships and the associated commercial agreements have allowed the experience of the gas cooled reactor programs in the Federal Republic to be brought to bear on the U.S. HTGR program and vice versa.

My testimony today will deal principally with the small, Modular HTGR which has received the major emphasis in the program during the past year. I will also address the status of the larger, Integrated HTGR design and the Thorium Recycle program which is under the direction of the Oak Ridge National Laboratory.

We believe that a significant impediment to the revitalization of the nuclear industry is the lack of confidence and acceptance of current nuclear systems and the nuclear infrastructures by significant segments of the public and other interested groups. This attitude may, in part, be ameliorated by the concerted effort being applied by utilities, suppliers, contractors and the government in their respective areas of responsibility. We believe, however, that a complementary approach of smaller, passively safe systems should be vigorously pursued. The benefits of nuclear energy are too great to ignore this alternative solution. We, at GA, fully supported the initiative for development and demonstration of an Inherently Safe Reactor System and believe that the HTGR class of reactor best meets the requirements.

MODULAR HTGR PROGRAM

The work on the DOE program during the past year has concentrated on detailed evaluations of several HTGR nuclear systems and overall plant configurations which could meet the criteria that were established by the program participants. These criteria evolved from a compilation of specific requirements related to safety and investment risk that are more stringent than current criteria, and take into account the full benefit of the inherent capabilities of the HTGR system and the experience gained on the actual design, construction and operation of these systems.

The intent of the program after the selection of a single preferred concept which occurred in February is to move rapidly toward a coordinated, multi-participant and project- oriented activity to demonstrate its features.

The preferred concept that has been identified as the U.S. design of a steel vessel modular HTGR. Each individual module would have a power output of 250 to 350 MW(t) and a reference plant concept would consist of multiples of these modules coupled to a single turbine generator. Each of the modules would incorporate a reactor core of HTGR-TRISO coated fuel particles in a graphite matrix. The physical dimensions and the power density of the core are determined by the requirement that under severe accident conditions the nuclear afterheat can be transferred by totally inherent conduction and/or radiation to totally passive heat removal systems. Under such conditions, the fuel particles would not reach temperatures which would cause significant fission product release from the coated particles. Radiation levels would be at a low level such that consideration of evacuation plans within the user's emergency planning would not be required and moreover the user's investment would not be jeopardized.

Assuming full credit is obtained from the licensing authorities for these features, considerable simplification of the total plant would be obtained since all of the nuclear requirements would be localized and the balance of the electricity generating plant could be built according to conventional construction standards. This separability factor, coupled with the ability to factory-fabricate the majority of the nuclear system, would lead to significant reduction in overall plant costs. The work to date has indicated that the multi-module 400 MW(e) plant can be made to be competitive under these assumptions.

Recognizing that the key assumption is the licenseability of the individual module, the participants in the program have proposed that the most logical approach to proving the principle would be to carry out a Licensing and Technology Test Project leading to a licenseability certificate from the NRC.

LICENSING AND TECHNOLOGY TEST PROJECT PLAN

The primary objective of the Licensing and Technology Test (LTT) Project would be to demonstrate the licenseability of the concept by the actual performance of a predetermined set of licensing basis events. These events would be determined in conjunction with the NRC and completion of the events with acceptable results would be the basis for the issuance of a "certificate of licenseability" for the concept.

A second and equally important objective of the project would be to validate the costs, schedule, equipment performance and investment risk protection capability of the concept. This would involve not only the close monitoring of work progress, but also significant design and performance reviews throughout the project and the actual performance of predetermined design basis events pertaining to equipment reliability and equipment failure and repair. This objective would be met through review and test specification procedures established in conjunction with a user group.

To meet these objectives in a cost-effective manner, GA recommends the following approach:

1. The performance of a LTT Project utilizing a single module become the defined goal of the DOE HTGR program and that the effort by the participants in the program be focussed on this activity as soon as possible.

2. The LTT project should be defined as a government project built on a government site.

3. The LTT project should be structured to permit the broad participation of qualified and interested organizations whose roles would be consistent with the effective utilization of each organization's pertinent background and experience.

4. Information provided to or developed in support of the the LTT project would be made available to all interested and qualified organizations at the government's discretion, with qualification that the rights of the participating organizations contributing to the project would be protected.

5. To the extent reasonable, the project would make use of technology available through cooperative international agreements.

GA believes that the Licensing and Technology Test project should be designated as a goal of the HTGR program as soon as possible. We would also recommend that the level of funding for the HTGR design and development program activities for FY'86 be increased from $26 million requested by the Administration to a level of $36 million. This program level would permit the program to progress at a more cost effective pace, permit significant licensing activities and the early initiation of Title I design activities for a LTT project. The House Science and Technology Committee recently reported its FY '86 DOE Research & Development authorization and we were pleased the Committee chose to support a $36M HTGR program initiating Title I Preliminary Design of a Modular HTGR.

GA Technologies is prepared to work together with the other industrial participants and the government to evolve an organization to effectively carry out such a project and to assure program access to pertinent technology and experience. We would, of course, also intend to continue to commit private resources to the support of the HTGR program.

INTEGRATED HTGR PROGRAM

Although the major effort on the HTGR program during the past year has been on the small, modular HTGR, there has been a continuing user interest in the so-called "Integrated" HTGR designs. These designs are characterized by configurations in which the reactor core and the primary loops are integrated within a single prestressed concrete reactor vessel.

A significant accomplishment during the year was the completion by the program participants of the conceptual design and related baseline documentation for the 2240 MW(t) [860 MW(e)] plant. This design, which represents 20% of the total engineering effort, has served as a benchmark for comparisons on costs, schedules, relative safety and investment risks between all of the other concepts. In particular, the design also served as a departure point for the consideration of smaller integrated plants and the potential for attaining an even greater degree of passive safety.

The integrated plants designs that were studied during the year were in the power output range of approximately 400 MW(e). Design improvements were incorporated in these designs to lead to increased levels of inherent safety and significantly reduced probabilities for significant fission product release.

We continue to believe that such integrated plants could also play a major role in the national energy picture. Both the integrated plants and the modular plants could be used for electricity generation and for the cogeneration of electricity and high temperature steam for use by process industries. Many of the larger utilities in the GCRA user group and other utilities with large installed capacities and reasonably large projected growth rates also foresee a possible role for these large integrated systems.

However, GA recommends that in the near term the program efforts be concentrated on the small modular concept and the LTT project.

THORIUM RECYCLE

The Spent Fuel Treatment Program, under the direction of the Oak Ridge National Laboratory, has been an integral part of the National HTGR program which has been supported and funded by your Committee. The information from this activity which focuses on the requirements, technology, and costs associated with the handling, transportation, processing and storage of discharged fuel is vital to the overall consideration of HTGR reactor systems.

The uranium/thorium fuel cycle for the modular HTGR designs utilizes low enriched uranium (LEU) fuel--approximately 20% enriched U-235. Management of the spent fuel for modular HTGRs on a once-through fuel cycle involves shipping and storage activities in various sequences prior to packaging and ultimate disposal of the HTGR spent fuel in a geologic repository. The cost of managing these back-end fuel cycle activities can be favorably impacted by the application of spent fuel treatment process technologies developed or under development in the United States and the Federal Republic of Germany as a part of an on-going cooperative program. In particular, volume reduction of HTGR fuel, which involves the removal of the graphite matrix from the fuel, produces a spent fuel in the form of TRISO-coated particles. These spent fuel particles are fully compatible with repository packaging and storage requirements. GA believes that the continued development of the spent fuel treatment processes are important to the overall HTGR effort and recommend continued government support for this activity including support for the U.S./Federal Republic of Germany cooperative spent fuel treatment program at a level of $3 million in FY'86.

SUMMARY AND RECOMMENDATIONS

In summary, Mr. Chairman, GA Technologies recommends that your Committee authorize the following for FY'86:

1. A funding level of $36 million (including $1 million for capital equipment) for the HTGR program with primary emphasis on the initial phases of a LTT project.

2. A funding level of $3 million for the Thorium Recycle program with primary emphasis on spent fuel volume reduction.

Thank you for the opportunity to present GA's views before your Committee.

The Chairman [presiding]. Thank you very much.
Mr. **Farley**.

STATEMENT OF EDWARD R. FARLEY, CHAIRMAN AND CHIEF EXECUTIVE OFFICER, ATLAS CORP.

Mr. **Farley**. Yes, Senator. Thank you.

I am chairman and chief executive officer of Atlas Corp., a publicly owned company whose shares are widely held and which owns a uranium mill and associated mines in the Moab, UT, area. I have been affiliated with Atlas and involved with the domestic uranium industry for 31 years.

Senator, it is beyond dispute that the domestic uranium industry is seriously depressed, and by no stretch of the imagination viable. We had 24 uranium mills operating about 3 years ago. There are five operating today, and none of them at capacity.

In 1980, we had 22,000 miners working in our industry. We have 2,000 working today. In 1980, we produced 43 million pounds of U-308 domestically. This year we will produce approximately 8 million, which level of production is less than a third of our domestic civilian requirements.

There is virtually no new exploration going on and no new capital investment. The current Nuexco spot market price is $14.25 per pound of U-308. At this price, the United States has essentially no reserves of uranium. We have zero reserves of uranium in this country.

The future is equally bleak. And within the past 12 months or more, practically all new contracts for uranium signed by U.S. utilities are for uranium produced abroad. The fact is that our industry is disappearing, and at a cataclysmic rate. It is not hard to determine the causes of our industry problems. Apart from Government regulations, the policies and projections of the Department of Energy and its predecessor have produced a glut of uranium.

In addition, there is foreign competition with which we cannot compete. Canada is the prime source of this foreign competition. It has heavily subsidized the uranium industry to the tune of more than $1 billion. It provides Government support to its producers through market allocations and it excludes domestic producers from selling into the Canadian market.

Given the inventory overhang due to previous U.S. policies and foreign government subsidies, it is impossible for our industry to compete against the terms and prices being offered for foreign uranium.

What are we going to do about it? The loss of a viable domestic uranium industry should be an important source of concern for our country. Broad interests of national security and energy independence are involved. Dependable and assured energy supplies are fundamental to our economy and to our national security.

The United States depends on nuclear energy today for about 13 percent of its electrical energy needs, and that percentage will grow through the rest of this century. A secure and reliable supply of nuclear fuel is essential to supply our Nation's needed electrical energy and dependency on foreign sources of supply does not compare favorably with the security of domestic supply.

I might say here, referring to Canada, that the Government of Canada has an upgrade in Canada policy which not only affects adversely our domestic conversion industry, but ultimately will affect adversely the viability of the Department of Energy's enrichment program.

Unless our Government acts to revise certain of our policies, we surely will lose our industry and be totally dependent on those foreign sources.

What can be done? In my submitted testimony, item No. 2 related to the Department of Energy choosing and appointing someone in that Department to whom we in the uranium producing industry could speak. There has been none such since the Grand Junction operation was closed many years ago.

At a meeting I had earlier this morning with Secretary Herrington, I was told that there is a nominee to fill that position, and I surely hope that he will be confirmed as soon as possible.

The first priority for help to our industry is some kind of a meaningful domestic use requirement. Perhaps this must take the form of legislation. Any such requirement should in effect limit the amount of foreign uranium employed in U.S. facilities to no more than 20 percent of domestic requirements. The exact percentage would depend on grandfather provisions and other factors.

I would say a domestic use requirement is not new, nor is it outside the scope of DOE's already existing authority. Section 161(b) of the Atomic Energy Act already requires DOE "to assure the maintenance of a viable domestic uranium industry."

In the past DOE and its predecessors have exercised this authority. We would like them to do so again. If the domestic industry is to be saved, then the Department of Energy should immediately implement an appropriate set of restrictions on the importation of foreign uranium and such restriction should remain in place at least until the market can recover from its current depressed condition.

Senator Domenici [presiding]. They have to find it. You're not viable first.

Mr. **Farley**. Well, we think the law requires DOE to act as the law stands, and that the the law is not being enforced, Senator. But I will have something to say about viability in a moment.

Senator **Domenici**. I'm just agreeing with you.

Mr. **Farley**. Right.

Senator **Domenici**. I mean when there is none, it still will be viable, I assume.

Mr. **Farley**. Second, the Department of Defense requirements and other governmental requirements for uranium should be filled with the uranium of domestic origin only. Actual Department of Defense requirements are somewhat unclear. However, the GAO reported not too long ago that the Department of Energy will have to obtain additional uranium for defense purposes in a few years.

In addition, it is interesting that the TVA is one of the largest importers of foreign uranium and perhaps the largest in our country.

Third, the Department of Energy should do whatever is possible to expand and encourage maximum demand for domestic uranium under its enrichment contract. I know that we may have lost our case on this, at least to some degree already, but we do not believe that Congress intended DOE's business enterprise to be conducted without due regard to its adverse impact on U.S. uranium producers.

In developing its enrichment policies, DOE should consider its obligation to maintain a viable domestic uranium producing industry. Specifically, the DOE should or should have make or made the variable tails options available immediately without upper limits or without surcharges to its enrichment customers supplying domestic feed.

(b) Cease the liquidation of Government uranium stockpiles, and if DOE plants are operated in the split tails mode, meet supplemental feed requirements from domestic uranium; and

(c) Offer incentive pricing for enrichment services only to those utilities supplying domestic feed.

Fourth, DOE should revise its regulations issued under section 170B of the Atomic Energy Act for assessing the viability of the domestic uranium industry. Those regulations totally misconceive the notion of viability. As the American Mining Congress testified last September, there could be no industry and DOE could and would deem it viable under the Agency's definition.

As could be expected under DOE's concept of viability, the Agency reported on December 31, 1984 that the domestic uranium producing industry was viable in 1983. We believe that this viability determination made a mockery of the law.

At the very least, Congress should insist that the Agency issue a timely determination now, not just for 1984, but for 1985, and that DOE use current data for this purpose, not data 3 or 4 years old.

I might say here I was disappointed in my meeting with the new Energy Secretary this morning when it was indicated to us that this determination for 1984 which I understood was to be made no later than June 1, was going to be made, or probably will not be made until sometime this summer. I don't believe that that much time is necessary at all.

In addition, DOE should base its determination on viability on a valid concept of viability, a concept which views the industry as viable if it is able to develop and grow within the confines of U.S. demand, not shrink and disappear. I think that's the kind of definition of viability one would find in Webster's dictionary.

We believe that DOE's initial concept of viability reflected congressional intent and the current one does not.

Fifth and finally, legislation should be enacted to provide an appropriate sharing of the cost of stabilizing tailings piles at active mills and decommissioning those mills. At the same time, Canada has poured more than $1 billion in cash into its uranium industry, United States uranium producers are being asked to expend $1 billion or more for remedial actions for uranium mill tailings at our existing processing sites. This cost is to be incurred, notwithstanding the fact that recognized experts' scientific opinion has stated unequivocally that the sites do not pose the kind of risk which warrants the costs involved.

Our beleagured domestic uraniun industry is in no position to bear all of these costs and to survive, particularly in view of the kind of support enjoyed by Canadian producers. I, being in the industry as long as I have, can testify to the fact that in the negotiation of perhaps five or six contracts with the Atomic Energy Commision, or amendments thereto, the idea that this danger was present and would have an ultimate cost never occurred and was never discussed.

As you know, 30 percent of the tailings at our domestic mills were generated under contract with the AEC, and we believe that we are entitled to some relief here. I know that you, Mr. Chairman, along with Senators Simpson and Bingaman, recently sponsored legislation designed to address this problem. We support totally that legislative effort.

Finally, Mr. Chairman, I recognize that the recommendations I've made above are not a one-way street. The Department of Energy would benefit from congressional review of the statutes covering its enrichment program. I believe that there is a general consensus in our industry in support of revisions to the laws governing the conditions under which DOE provides its enrichment service.

The point I wish to make clear is that our industry objective should be a vigorous American nuclear fuel industry and that includes both DOE's enrichment program and private uranium suppliers.

In closing, I wish again to express our appreciation for your interest in attempting to help us restore a viable domestic uranium-producing industry. The one point I want to make clear is that, absent U.S. Government intervention and assistance, our domestic uranium industry in the future will totally disappear.

This Nation will be in exactly the same state of dependency on imports which we sought to avoid when we developed a domestic uranium industry some 40 years ago. The only differences between now and then are that our uranium requirements are now greater.

As a corrollary, the reason to seek to assure the maintenance of a viable domestic uranium industry should correspondingly be greater. The basic question here, gentlemen, is whether our Government wants a domestic uranium-producing industry. If it does, it must help us—and soon. If it doesn't, we who are still left in that industry will accept that fact and we will go our own way. The choice is yours.

Thank you.

[The prepared statement of Mr. Farley follows:]

TESTIMONY OF
MR. EDWARD R. FARLEY
BEFORE THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
OF THE
SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

Mr. Chairman and members of the Committee, my name is Edward R. Farley. I am Chairman and Chief Executive Officer of Atlas Corporation, a publicly owned company whose shares are widely held and which owns a uranium mill and associated mines in the Moab, Utah area. I have been affiliated with Atlas and involved with the domestic uranium industry for over 30 years.

Mr. Chairman, it is beyond dispute that the domestic uranium industry is seriously depressed and by no stretch of the imagination viable. Only 5 of the Nation's 24 uranium mills are in operation, and all of these are operating at reduced capacity. Only about 2,000 of the Nation's 22,000 uranium miners are still at work. U.S. uranium production this year is now expected to be less than 8 to 9 million pounds -- and that figure includes by-product production from Florida phosphate lands. This level of production is less than a third of U.S.

civilian requirements. There is virtually no new exploration or capital investment. More than $300,000,000 of investment has been written off by four uranium companies in this year alone.1/ The current Nuexco spot market price is in the $14 to $15 range. At this price, the United States has essentially no reserves of uranium.

The future is equally bleak. As existing contracts with domestic producers expire, they are not replaced. Virtually all new contracts for uranium signed by U.S. utilities are for uranium produced abroad. Colorado Nuclear Corporation, the consulting firm which devised the computer model employed by DOE to project the uranium industry, estimates that, absent a change in government policy, the share of the U.S. market supplied by domestic producers will continue to decline, both absolutely and relatively, through the turn of the century, and that at that time the market supplied by our domestic industry will be only a few million pounds per year.2/ A survey conducted by the American Mining Congress late last year found that there would likely be only 3 mills left by 1990 out of 24

1/ Plateau Resources, Quivira Mining, Western Nuclear, UNC. See, e.g., Kerr-McGee Press Release (Jan. 16, 1985); Wall Street Journal, Feb. 25, 1985 at p. 8 (United Nuclear).

2/ Colorado Nuclear Corporation, Review and Critique of "United States Uranium Mining and Milling Industry A Comprehensive Review" (Sept. 1984).

mills operating a few years ago.3/ I think it additionally dire and foreboding that one of those three has now suspended operations.4/ The fact is that the domestic uranium industry is disappearing, and it is doing so at a cataclysmic rate. The attached charts, recently prepared by the American Mining Congress, aptly portray the situation.

Mr. Chairman, roughly eight months ago, your Subcommittee held hearings on the status of our industry. Presidents of five uranium companies testified. Today, three of these five executives have "retired" or are on the verge of "retirement." I think this kind of voting with one's feet is powerful evidence of the industry's present and projected future.

Causes of the Problem

It is not hard to determine the cause of the industry's problems. During the 1970's the Atomic Energy Commission and its successors, ERDA and DOE, projected a rapid expansion in nuclear generating capacity,5/ and followed policies encouraging the development of foreign enrichment facilities and

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3/ See Affidavit of Larry A. Boggs and attached Letter, Mr. Stevens to Mr. Hodel, Dec. 28, 1984.

4/ Pathfinder (Gas Hills, Wyoming). See Riverton Ranger, Feb. 19, 1985).

5/ See Uranium Enrichment: Heading for the Abyss, 221 Science 730, 731 (1983).

requiring the utility industry to contract for enrichment services far in advance of need. This forced utilities also to contract for uranium well in advance of when it was needed. When installed nuclear capacity grew much more slowly than expected, a glut of stockpiled uranium and enriched uranium built up.6/

This glut has had an obvious depressing effect on domestic uranium producers. The stockpile overhang and competition from new foreign enrichers also has put pressure on DOE to revise its enrichment policies. In response, DOE in early 1984 issued a new generic enrichment contract. This contract, which was worked out with DOE's customers, was prepared and issued without the input of the domestic uranium producing industry.7/ It contains a number of features which further reduce demand for uranium.8/ Outside experts have in fact estimated that DOE's new enrichment contract decreases demand by 50,000,000 to 100,000,000 pounds over the next 5 to 10 years.9/ This is a

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6/ The effect of the federal government's policies was predicted by Vince Taylor in How the U.S. Government Created the Uranium Crisis (And the Coming Uranium Bust), June 1977, reprinted in Hearing before the Energy Research and Dev. Subcomm. of the Senate Energy and Natural Resources Comm., 95th Cong. 2d Sess. 143 (1978).

7/ *See* Affidavit of Larry A. Boggs.

8/ Some of these features are discussed in Letter, Mr. Stevens to Mr. Hodel, January 10, 1984 attached to Boggs Affidavit.

9/ *See*, *e.g.*, Nuclear Resources International, DOE Enrichment Policies and the U.S. Uranium Industry (Sept. 1984).

death knell for many domestic producers, and several have folded their tents and quietly expired since issuance of the contract.

While the domestic uranium industry of course recognizes the need for DOE to revise its enrichment policies, many producers feel that the revision should have -- and could have -- been accomplished in a fashion less harmful to an already troubled domestic producing industry.

Another problem has been the rapid increase in commitments for import of foreign source uranium. The principal source for this uranium is Canada. Canada has heavily subsidized its uranium industry to the tune of more than a billion dollars.10/

10/ Eldorado Nuclear Limited (which has long been owned by the Canadian government) in recent years has received an additional approximately $300,000,000 in uranium from the Canadian government stockpile in return for stock. A $100,000,000 loan to an Eldorado subsidiary was forgiven and a gain of roughly $25,000,000 was realized. See Eldorado's 1981 Annual Report at 2 and 25. The Province of Saskatchewan owns the Saskatchewan Mining Development Corporation (SMDC). The Province has provided approximately $250,000,000 in equity advances to SMDC and has also provided or guaranteed certain long-term debts of SMDC. SMDC 1983 Annual Report. Ontario Hydro (owned by the Province of Ontario) has advanced Denison and other Canadian uranium producers in excess of $600,000,000. See, e.g., Wall St. J., Oct. 8, 1981 ($600,000,000 interest free loan to Denison and Rio Algom); Nuclear Fuel, Jan. 4, 1982 ($600,000,000 plus); Nuclear Fuel, March 28, 1983 ($600,000,000 at one project). Government owned Canadian companies are major participants in virtually all Canadian uranium projects. The remainder are financed in large part by the Province of Ontario through Ontario Hydro.

It provides government support to its producers through market allocations and exclusion of U.S. producers, and reviews and controls the terms and prices of uranium export contracts.11/ Foreign producers have been encouraged to sell their surplus products on the U.S. market12/ -- which is in essence the only market with unfilled requirements currently available. Given the inventory overhang due to previous U.S. policies, and the foreign government subsidies, it is impossible for U.S. producers to compete against the terms and prices being offered for foreign uranium. That is why almost all new contracts by U.S. utilities involve foreign supplies.

To repeat, our domestic industry is disappearing. Mines and mills cannot be kept on suspended status indefinitely. First, that costs money -- money which is a total loss when no uranium is being produced. Second, eventually federal and state reclamation laws will be applied. Mills will be decommissioned and licenses terminated.13/ Mines will be

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11/ See, e.g., Statement by The Honorable Donald S. MacDonald, Minister of Energy, Mines and Resources in Canada's Uranium Policy (Sept. 5, 1974); Pricing Policy published March 1977; Ontario Uranium Mining Industry -- Past, Present and Future by O.J.C. Runnalls (Jan. 1, 1981).

12/ "[W]e are strongly encouraging [Canada] producers to export their surplus [to] the United States..." Notes for an address, The Honorable Marc Lalande, Minister of Energy, Mines and Resources, June 22, 1981.

13/ See CNC, note 2, at p. 30:

(Continued Next Page)

flooded. And once mines are flooded, it is dangerous, expensive, and in many cases likely impossible to recover any reserves remaining in those mines. Within a few years, this Nation risks the loss of its domestic uranium capacity.

A Concern for the Nation

The loss of a viable domestic uranium industry should be an important source of concern. At the personal level, there is obviously the concern one must feel for the 20,000 unemployed and displaced uranium miners and their families, and the disruption to the small western communities where this is most felt. However, broad interests of national security and energy independence are also involved. Dependable and assured energy supplies are fundamental to our economy and our national security. The United States depends on nuclear energy for some 13 percent of its electrical energy needs. The percentage is much

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(Continued)

> "'excess' production capability will rapidly erode as producers shut down facilities and enter into decommissioning and reclamation as directed by the state and federal regulations which govern uranium production facilities. It is highly doubtful that the state authorities will allow the open-ended shutdown of uranium mines and mills. Pressure will be applied to decommission and reclaim after a relatively short period of inactivity."

higher in many of our states. Moreover, the percentage is on the increase and will continue to increase at least through the turn of the century. A secure and reliable supply of nuclear fuel is essential to supply our Nation's needed electrical energy. Dependency on foreign sources of supply does not compare favorably with the security of domestic supply. Many foreign sources are in politically unstable regions of the world.14/ DOE has in the past indicated that foreign production is subject to embargoes and cartel pricing.15/ This is not a hypothetical threat. Canada actually embargoed export contracts at one point in the 1970's.16/ Congress has already investigated evidence of a foreign uranium cartel sponsored by foreign governments in the 1970's.17/ And the Australian Labor Party

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14/ In the words of Robert Rich, until recently the nuclear fuel manager for the Yankee utilities,

> "When one considers that well over half of the western world's uranium resources are in areas that have been commonly characterized as politically unstable, there's a large potential for market disruption by political events." Nuclear Fuel, Feb. 11, 1985, at p. 8.

15/ DOE, The Domestic Uranium Industry and Imports of Uranium 36-37 (Feb. 23, 1981).

16/ Nuclear Fuel, 7/11/77 p. 9; 8/8/77 p. 1; 1/9/78, p. 1.

17/ *See* Hearings before the Subcommittee on Oversight and Investigation of H. Comm. on Interstate and Foreign Commerce (1976-78) ("Moss Hearings").

flirts with cutting off uranium production.18/ Under these circumstances, it is clearly ill-advised to develop a dependency on foreign sources of supply.

There is another important reason to be concerned. The government of Canada has an upgrade-in-Canada policy. Under this policy, Canada requires foreign buyers to purchase not only Canadian uranium but also Canadian conversion services. This policy already threatens the U.S. conversion industry. If the Canadian government builds an enrichment facility, it would clearly impact adversely the viability of DOE's enrichment program.

In the past, Congress has recognized that the nuclear fuel cycle must be viewed as a whole, and that the uranium component is an integral and vital part.19/ This recognition is proper

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18/ Nuclear Fuel, 7/30/84 p. 11.

19/ In the words of the Joint Committee on Atomic Energy,

> "the maintenance of a viable domestic uranium industry is an integral part of a sound nuclear industry..." 1964 U.S. Code Cong. & Admin. News 3132.

The Joint Committee also noted that assurance of a viable domestic uranium industry is

> "in the national interest since this industry is related to our national defense and security." Id. 3121.

and correct. If our Nation loses its uranium industry, the nuclear option is a house without a foundation.

Solution

Mr. Chairman, unless the government acts to revise certain of its policies, we will lose our domestic uranium industry and we will be almost totally dependent on foreign sources of supply for nuclear fuel. It is the position of the domestic uranium producers that the federal government has authority under existing law to address this situation. Unfortunately, this authority is not being exercised. Accordingly, additional legislation is probably necessary. The important point is that the government must act soon. I would like to present some actions which can and should be taken.

1. A number one priority is some kind of meaningful domestic use requirement. Perhaps this must take the form of legislation. Any such requirement should in effect limit the amount of foreign uranium employed in U.S. facilities to no more than 37 1/2 percent of domestic requirements. The exact percentage would depend on grandfather provisions and other factors. With full grandfathering, a higher percentage is necessary to assure meaningful relief.

I would note that a domestic use requirement is certainly not new, nor is it outside the scope of DOE's already existing authority. Section 161v. of the Atomic Energy Act already requires DOE to "assure the maintenance of a viable domestic uranium industry."20/ In the past, DOE and its predecessors have exercised their authority under this provision to limit the importation of uranium or enriched uranium during periods of limited demand -- precisely the condition currently faced by domestic producers.21/ DOE's predecessor agency actually testified that relief under Section 161v. was the desirable means to deal with uranium issues because this was the statute specifically designed for that particular commodity.22/ If the domestic industry is to be salvaged, the Department of Energy

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20/ 42 U.S.C. § 2201(v).

21/ DOE's predecessor, the Atomic Energy Commission (AEC), imposed domestic use requirements from 1966 through 1983. The decision to phase out the requirements was based on erroneous forecasts of vastly increased U.S. and worldwide demand for nuclear power and uranium.

The AEC testified in 1963 and again in 1974 that for purposes of assuring the viability either of the domestic uranium industry or DOE's own enrichment business, the Atomic Energy Act authorizes imposition of restrictions on the importation of both natural uranium ("source material") and enriched uranium ("special nuclear material") in the form of conditions on the import licenses required by the Atomic Energy Act for all such imports. See, e.g., Private Ownership of Special Nuclear Materials, Hearings before the Subcomm. on Legislation of the Jt. Comm. on Atomic Energy, 88th Cong., 1st Sess. at 30 (General Counsel Hennessey); Proposed Modification of Restrictions on Enrichment of Foreign Uranium for Domestic Use, Hearings before the Joint Comm. on Atomic Energy, 93rd Cong., 2d Sess. 8 (1974); id. at 233 (AEC letter).

22/ 1974 Hearings at 8-9.

should immediately implement an appropriate set of restrictions on importation of foreign uranium and such restrictions should remain in place at least until the market can recover from its current depressed condition. Given DOE's reluctance to act, Congress should itself impose an appropriate domestic use requirement.

2. There is currently no policy-level official at the DOE with whom domestic uranium producers can productively discuss the problems of our industry. A high level official in the Department of Energy should be assigned responsibility for the domestic uranium industry. Previously, DOE devoted an entire office to this task. The office, however, was phased out. As a result, there is no adequate or timely analysis of the impact of DOE actions upon domestic uranium producers.

3. Department of Defense requirements, and other government requirements for uranium, such as those of the Tennessee Valley Authority, should be filled with uranium of domestic origin. Actual DOD requirements are somewhat unclear. However, the GAO has recently reported that DOE will have to obtain additional uranium for defense purposes in a few years.23/ As to TVA, it is the height of irony that that agency, which earns so

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23/ GAO, Information on DOE's Costing and Pricing of Uranium Enrichment Services (GAO/RCED-84-156) at p. 17 (April 25, 1984).

much as an electrical supplier to DOE's enrichment program, should be one of this country's largest uranium importers. Requiring U.S. agencies to buy their uranium American can go a long way to supplying the short-term demand we need to keep this industry alive.

4. DOE should also do what is possible to expand demand for domestic uranium under the enrichment contract. A prime example involves the so-called variable tails" issue. The current contract limits and penalizes an enrichment customer's selection of tails assay. This has the effect of increasing demand for enrichment services and reducing demand for uranium by 3 to 5 million pounds per year -- an amount equivalent to the output of several good-sized uranium mills. DOE at the same time plans to operate its enrichment plants at a tails assay approaching 0.35.24/ This will require supplemental feed from the government stockpile. In effect, DOE is transferring uranium demand from the private sector to itself. This may assist the agency in holding down its costs,25/ but it is a tough pill

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24/ *See*, *e.g.*, DOE Interim Operating Scenarios.

25/ DOE has specifically noted that the principal reason it is contemplating this "split-tails" operation is to subsidize its enrichment price under its new contract. *See* Review of the Status of the U.S. Domestic Uranium Mining and Milling Industry, Hearing Before the Energy Research and Dev. Subcomm. of the Senate Energy and Natural Resources Comm., 98th Cong., 2d Sess. at 48 (1984).

to require beleaguered uranium producers to swallow. I would note in this regard, Mr. Chairman, that DOE's recently announced "incentive pricing" scheme for marginal SWU's will provide little or no stimulation for demand for domestic uranium. It represents another missed opportunity.

5. DOE should revise its regulations issued under Section 170B of the Atomic Energy Act for assessing the viability of the domestic uranium industry.26/ Those regulations totally misconceive the notion of viability. In an Orwellian fashion, they define a viable industry as whatever industry is needed, if any, to supply incremental demand, if any, after stockpiles are taken into account, in the event of a hypothetical unspecified import disruption.27/ This is so absurb it is ridiculous. As the American Mining Congress testified last September, there could be no industry and DOE could and would deem it viable under the agency's definition. As could be expected under DOE's concept of viability, the agency reported (in a document dated December 31, 1984) that the domestic

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26/ See 48 Fed. Reg. 45746 (October 6, 1983).

27/ DOE acknowledged that its regulation "conceives of a viable domestic uranium industry as an industry capable of meeting increases in demand if there is some unspecified import disruption after you take stockpiles into account." Review of the Status of the U.S. domestic Uranium Mining and Milling Industry, Hearing before the Subcomm. on Energy Research and Dev. of the Senate Comm. on Energy and Natural Resources, 98th Cong. 2d Sess. 51 (1984).

uranium producing industry was viable in 1983.28/

Mr. Chairman, DOE's concept of viability and its recent viability determination make a mockery of the law. At the very least, Congress should insist that the agency issue a timely determination now - not just for 1984, but for 1985 -- and that DOE use current data for this purpose -- not data three or four years old. In addition, DOE should base that determination on a valid concept of viability -- a concept which views the industry as viable if it is able to develop and grow within the confines of U.S. demand, not shrink and disappear. DOE initially proposed to define a viable domestic uranium industry as one capable of supplying substantially all U.S. requirements within two years but it abandoned that concept. We believe that DOE's initial concept of viability reflects Congress' intent and that the later definition on which DOE is basing its viability determinations does not.

28/ DOE's determination for the year 1983 was issued under documents dated December 31, 1984. In 1982, DOE's Grand Junction Area Office, which until it was disbanded in 1983 was in charge of evaluating the domestic uranium industry, issued a draft report concluding that under expected market conditions, "the U.S. Uranium industry can hardly be regarded as being viable." DOE GJAO, Status of the U.S. Uranium Producing Industry (182). Conditions have further deterioriated since the 1982 report became public. The conclusion of the Grand Junction Office is the only one that can withstand scrutiny.

6. At the same time Canada has poured more than a billion dollars in cash into its uranium industry, U.S. uranium producers are being asked to expend a billion dollars or more for remedial actions for uranium mill tailings at our existing processing sites. This cost is being incurred notwithstanding the fact that recognized expert scientific opinion has stated unequivocally that the sites do not pose the kind of risk which warrants the costs involved.29/

Mr. Chairman, our beleaguered domestic uranium industry is in no position to bear the costs and survive, particularly in view of the kind of support enjoyed by Canadian producers. As stated above, almost all new contracts by U.S. utilities are for foreign uranium. Domestic producers thus have no sales through which to obtain funds for the remedial measures, and domestic producers are simply not in a position to pass them through to anyone. In addition, Mr. Chairman, domestic producers had no idea that such stringent and expensive remedial measures would be required when the vast majority of the tailings were generated.

29/ *See*, *e.g.*, EPA Radon and Radionuclide Emission Standards, Hearing before the Procurement and Military Nuclear Systems Subcomm. of the House Armed Services Comm., 98th Cong., 1st Sess. (1983) (testimony of Dr. Warren Sinclair, NCRP; testimony of Dr. Leonard Hamilton, Brookhaven; et al).

Permit me to make one illustration: 30% of the tailings at U.S. uranium mills were generated under contracts with the Atomic Energy Commission.30/ The basic intent of these contracts was to reimburse uranium producers for their costs and to assure a reasonable profit.31/ The parties neither understood nor contemplated that extensive or expensive measures would be required for purposes of ultimate stablization, or they would have incorporated appropriate reimbursement for the cost of such measures in the contracts.32/ As the General Accounting Office has said,

> "The mill owners apparently acted in good faith in carrying out their responsibilities in meeting contract provisions and Federal Regulations. Unfortunately, like the Federal Government, they did not recognize that the tailings were a potential health hazard and did not provide for their control. Now, the Federal Government is requiring the mill owners to clean up all of the tailings, including those generated before the hazard was recognized. We believe it is unfair for industry to bear all of the costs in cleaning up the

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30/ Cf. DOE, Commingled Tailings Study, Vol. 1 (June 30, 1982) reprinted in Management of Commingled Uranium Mill Tailings, Hearings before the Procurement and Military Nuclear Systems Subcomm. of the House Armed Services Comm., 97th Cong., 2d Sess. at 540 et seq. (1982).

31/ See, e.g., Deposition of Elton Youngberg (former General Manager, AEC-Grand Junction) at 8; Deposition of Frank McGinley (former Assistant General Manager, AEC-Grand Junction) in Atlas v. U.S., Claims Court No. 281-83C at 18-19.

32/ See, e.g., Deposition of Elton Youngberg at 10, 20; Deposition of Frank McGinley at 27-31.

tailings."33/

Mr. Chairman, as you know, DOE issued a so-called "plan" to deal with these AEC-related tailings34/ but has taken no action to provide any financial contribution. Again this year, the DOE authorization bill is silent on this score. You, along with Senators Simpson and Bingaman, recently sponsored legislation designed to address the problem of a fair allocation of these remedial action costs. We support that legislative effort.

7. Finally, Mr. Chairman, I recognize that the recommendations outlined above are not a one-way street. The Department of Energy would benefit from congressional review of the statutes governing its enrichment program. I believe that there is a general concensus in the uranium industry in support of revisions to the laws governing the conditions under which DOE provides its enrichment services. The revisions could allow DOE better to address the competition it is facing from foreign-government-owned enrichers -- competitors which DOE has stated are enjoying subsidies from their governments. The point I wish to make clear, Mr. Chairman, is that our principal objective should be a vigorous American nuclear fuel industry,

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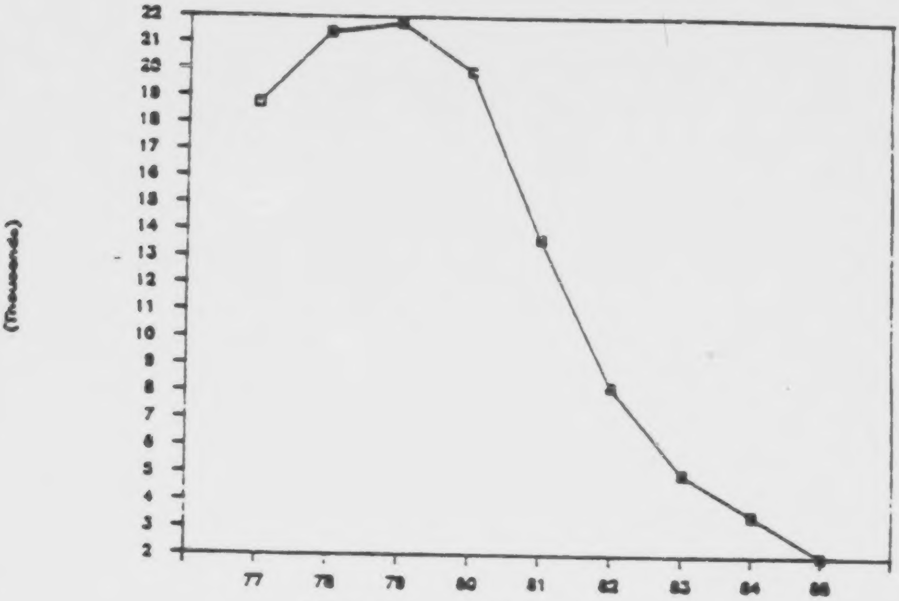
33/ GAO, "Cleaning Up Commingled Uranium Mill Tailings: Is Federal Assistance Necessary?" at p. 1 (1979).

34/ *See* note 30 *supra*.

and that includes both DOE's enrichment program and private uranium suppliers.

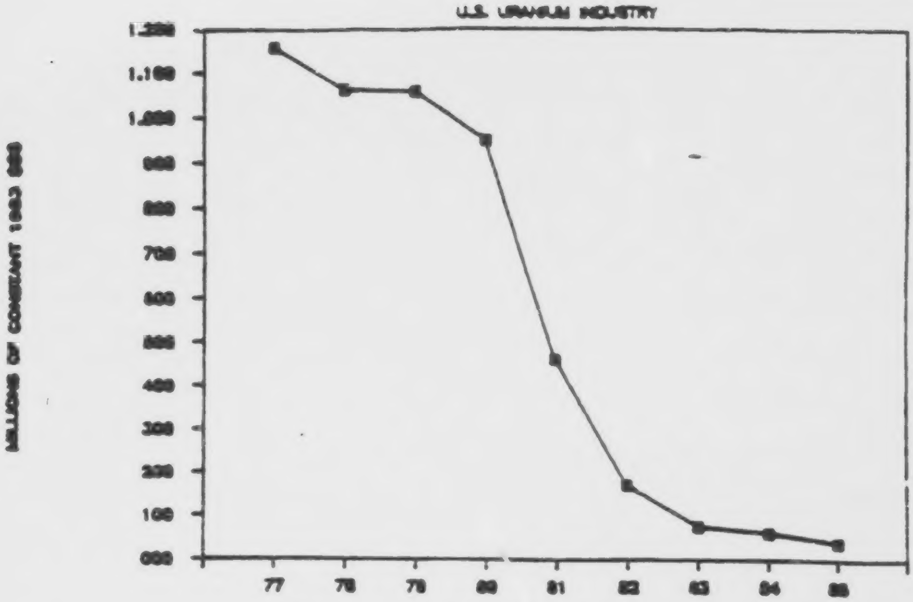
Conclusion

Mr. Chairman, in closing I wish to underscore our appreciation for your interest in restoring a viable domestic uranium industry in this country and your leadership in attempting to address this situation. The one point I wish to make crystal clear is that, absent U.S. government intervention and assistance, our domestic uranium industry in the near future will almost totally disappear. This Nation will be in exactly the same state of dependency on imports which we sought to avoid when we developed a domestic uranium industry some 40 years ago. The only differences between now and then are that our uranium requirements are now greater. As a corollary, the reasons to seek to assure the maintenance of a viable domestic uranium industry should correspondingly be greater.



U.S. URANIUM INDUSTRY EMPLOYMENT

Source: U.S. DOE. Industry Estimates



Source: U.S. DOE. Industry Estimates

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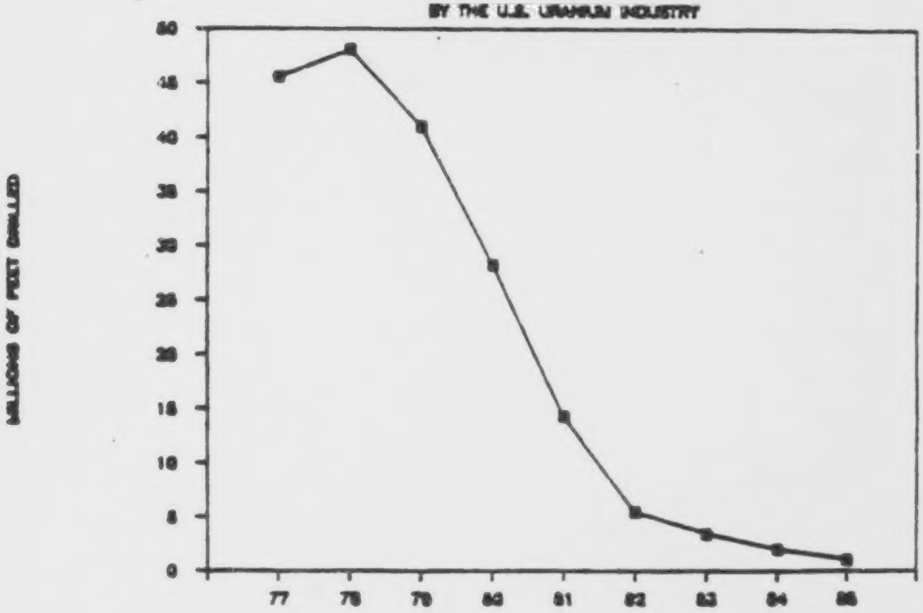

Source: U.S. DOE, Industry Estimates

Senator DOMENICI. Thank you very much.
Mr. Boyer.

STATEMENT OF VINCENT S. BOYER, CHAIRMAN, GAS-COOLED REACTOR ASSOCIATES

Mr. BOYER. I am Vincent S. Boyer, senior vice president for Nuclear Power, Philadelphia Electric, and I'm speaking today in my position as chairman of the Gas-Cooled Reactor Associates.

I have been associated with the Gas-Cooled Reactor Program since 1960 when I was appointed superintendent of the Peach Bottom Gas-Cooled Reactor. That plant, as you will recall, operated successfully from 1967 to 1974 and set the path for the further development and utilization of gas-cooled reactors here in the United States.

I will briefly highlight my remarks and request that my prepared testimony be entered in the record.

The Gas-Cooled Reactor Associates was formed in 1978 by a group of utilities representing approximately one-third of the U.S. utility generating capacity who had an interest in the gas-cooled reactor concept and saw its potential. We were joined by several large industrial users, since the gas-cooled system provides opportunities for not only cogeneration, but also process heat.

The goal of Gas-Cooled Reactor Associates is to establish the high-temperature gas-cooled reactor as a viable commercial alternative, and we plan on doing this up through the development and commercialization of the steam cycle.

The role which we are providing is a leadership role in the project development activities, and in providing coordination support for the DOE effort.

During past years, we have optimized and simplified the large 900-megawatt prismatic block gas-cooled reactor. We have worked further in recent times, looking at smaller systems, and we are intrigued further by these due to their small size, simplicity, minimum dependence on engineering safety systems, on the economics of the power production system which was of course inherent with the gas-cooled reactor, and on the low radiation release and exposures which are experienced in gas-cooled reactor plants.

Dr. Dance has described some of the efforts which have gone on in the past and are currently going on. The work in the past year evaluated four small modular type reactors which could be built in a fairly short timeframe, on the order of 3 years or so, thus minimizing interest during construction costs and which could be factory-fabricated.

We have decided on pursuing a steel vessel modular concept as the reference design, and we are working toward the further development of that design and the development of a licensing and technology test facility which will establish and verify the project advantages.

I might note that in our process, we have developed a user design manual. Senator McClure asked whether the utilities or the users were involved in setting the parameters, and this is one thing that we have done through our technical advisory committee. We have met and said what do we really want this plant to do; what criteria must it meet; and have established a document listing those parameters.

Our recommendation for the DOE's 1986 program is for continued level of a $38 million support, basically the level continuing from 1985. And our major effort will be the preparation of a preliminary safety information document which is basically similar to a preliminary safety analysis report for a light-water reactor.

We will have considerable involvement with the Nuclear Regulatory Commission in establishing the safety requirements and parameters which this plant which has certain inherent advantages must meet.

In summary, we are calling on the DOE for support of this effort and continued development of the licensing and technology test program. And we appreciate the support which you and your committee have given us in the past.

Thank you.

Senator DOMENICI. Thank you, Mr. Boyer. Your entire statement will be made a part of the record.

[The prepared statement of Mr. Boyer follows:]

STATEMENT SUBMITTED FOR THE RECORD
SUBCOMMITTEE ON ENERGY RESEARCH AND PRODUCTION
COMMITTEE ON ENERGY AND NATURAL RESOURCES
UNITED STATES SENATE

FY 1986 DOE AUTHORIZATION
HIGH TEMPERATURE GAS-COOLED REACTOR PROGRAM

VINCENT S. BOYER
SENIOR VICE PRESIDENT, NUCLEAR, PHILADELPHIA ELECTRIC COMPANY
AND
CHAIRMAN OF GAS-COOLED REACTOR ASSOCIATES MANAGEMENT COMMITTEE

Mr. Chairman and Members of the Subcommittee, my name is Vincent S. Boyer, and I am Senior Vice President of the Philadelphia Electric Company and Chairman of the Gas-Cooled Reactor Associates (GCRA) Management Committee. GCRA is a utility/user organization that supports the development of the High Temperature Gas-Cooled Reactor (HTGR). At present, the GCRA constituency represents approximately one-third of the installed generation capacity in the U.S. In addition, participating GCRA utilities have a substantial investment in and extensive experience with nuclear power. This background of nuclear experience provides GCRA with a sound base for evaluating the HTGR as a commercial alternative. GCRA's role is to apply this base of experience in guiding the development of the HTGR to be fully responsive to utility/user requirements. A GCRA staff, supported solely by utility funds, has been in place since 1978 conducting HTGR concept evaluations, Project planning and development activities, and Program coordination support services to DOE, including the management of architect-engineer (AE) resources.

The bases for utility/user interest in the HTGR are the unique characteristics that distinguish it from the current generation of nuclear power systems. The most notable of these features are the inherent safety and low environmental impact characteristics that translate to minimal reliance on engineered safety systems, substantial time (measured in hours) for operator response to postulated reactor upset conditions, added margins for plant investment protection and siting flexibility, and low radiation exposure of plant personnel. Furthermore, the HTGR is an evolutionary technology that extends beyond near-term power and cogeneration applications to advanced concepts for power generation and process heat. At the Philadelphia Electric Company, we are strong believers in these advantages and proud of our demonstration role through the first U.S. HTGR prototype plant - Peach Bottom I.

From its inception in 1978, GCRA's objective has been to establish the HTGR as an attractive commercial alternative for a broad range of applications in a timely manner. The approach to achieving this objective has been to establish an initial HTGR Project after which commercial plants can be deployed. In achieving this objective, the maximum use will be made of the past 35 years of worldwide gas-cooled reactor technology, demonstration and application. In the near-term, the objective is to develop an HTGR design that is responsive to the utility/user's requirements, eases the current institutional difficulties associated with nuclear power and optimally capitalizes on the HTGR's unique characteristics.

During the past year, a comprehensive evaluation effort has been undertaken within the HTGR Program of various smaller, simpler HTGR design concepts. Through this effort, a consensus has been reached among the private-sector participants on the key elements of the HTGR Program. In particular, the preferred concept for near-term development and deployment emphasis is the steel vessel, modular design. Resources for the near-term, including the balance of 1985, should be focused on pursuing this concept to establish whether there is a sufficient basis for Project commitment. Key distinguishing features of the modular HTGR include:

1. The core size and power density are limited such that the fuel particle coatings retain the fission products to an acceptable degree under all licensing basis events, with decay heat removal being accomodated by the passive mechanisms of radiation and conduction. This feature is expected to simplify the overall concept, particularly the licensing and operations activities.

2. The nuclear steam supply system and other systems within the nuclear island are shop fabricated and assembled to nuclear standards, while the balance of plant is largely manufactured and constructed to conventional fossil plant standards. This is expected to improve the productivity and reduce the schedule and field erection costs.

3. The plant is composed of independent reactor units of approximately 250 MWt/100 MWe that can be constructed as a cluster of modules or sequentially constructed to more closely match load growth requirements and the utility's financing constraints.

The preferred strategy for deploying the modular HTGR is through a Licensing and Technology Test Project that would be used to implement the "license by test" concept as well as to demonstrate the performance, cost and schedule features of the modular HTGR. Further, international cooperation, particularly with the Federal Republic of Germany, should be expanded to the maximum degree in order to reduce the overall costs and risks to the U.S.

A major ongoing effort within GCRA has been to coordinate the private-sector efforts in support of such a Project initiative. To this end, exploratory activities are underway to establish a consolidated vendor/supplier/AE entity that can efficiently design and build the Licensing and Technology Test Project. The intent is that upon successful completion, multiple vendor entities would be able to offer commercial modular HTGR plants. In addition, efforts are continuing to establish the detailed utility/user requirements of such a Project, candidate sites, host or supporting utility arrangements, as well as arrangements for broad utility support for the Project.

With regard to DOE's HTGR budget for FY 1986, it is recommended that the Program be funded at a minimum level of $38 million, including $2 million for capital equipment. The emphasis of the DOE Program should be on advancing the design of the reference modular HTGR and the preparation of a Preliminary Safety Information Document (PSID) which will be used as a basis for NRC review and issuance of a licensability statement. In addition, a Licensing and

Technology Test Project Plan should be prepared for support of the FY 1987 budget request. Government support for the proposed budget level would be invaluable in nurturing the continued development of private-sector and international support for a Project commitment plus provide strong evidence of the U.S. support for revitalizing nuclear power.

Finally, I would like to update you on the Fort St. Vrain power plant. Last year, it was reported to the Subcommittee about the improving performance of the plant during 1983, but unfortunately, this trend did not continue through 1984. On January 20, 1984 the plant underwent a planned shutdown for its third refueling along with an extensive refurbishment and maintenance program that lasted until the second week in June. Shortly after the plant was restarted, a plant upset occurred which resulted in a significant ingress of water into the primary coolant system via the helium circulators' bearing seals. In the subsequent safe shutdown, it was observed that six pairs of control rods failed to drop into the reactor. While this event in itself posed no safety hazard, the subsequent investigation revealed that excess moisture in the primary helium system had caused a corrosion problem in the control rod drives. During the past months, Public Service Company of Colorado has made the appropriate improvements at the plant and is currently refurbishing the control rod drives. It is anticipated that the plant will be able to be restarted in the next few months.

In spite of such first-of-a-kind difficulties, it should be recognized that Fort St. Vrain has provided critical confirmation and demonstration of many inherent HTGR features. For example, the amount of radioactivity carried in the helium coolant has been less than two percent of the design limit, demonstrating the structural integrity of the coated fuel particles. Personnel exposure data for the U.S. indicate that Fort St. Vrain has had an average annual person-rem exposure rate per GW(e)-year approximately a hundred times lower than the rate in light water reactor plants. This low personnel exposure level is probably the lowest of any commercial nuclear plant in the world and is even more significant in view of the fact that Fort St. Vrain allows virtually unlimited access into the reactor building for all operations and maintenance personnel. As another example, temperature transients have been slow and predictable, even during periods of temporary loss of forced cooling, demonstrating the large heat capacity of the core. Operation to date has achieved 1000^{o}F steam temperatures and a net efficiency of 38.5%--the highest of any nuclear plant in the U.S.

As part of a continuing commitment to improve the performance of Fort St. Vrain, Public Service Company of Colorado plans to spend about $16 million in subsequent HTGR designs. For example, a new helium circulator design, possibly using an electric motor drive and magnetic bearings that do not require water, is being investigated for possible application in the modular HTGR and might even be able to replace the existing circulators in Fort St. Vrain.

Mr. Chairman, I appreciate the opportunity to present the utility/user support and perspective on the HTGR Program to your Subcommittee. With your continued support, we will bring to fruition an HTGR Program that is responsive to utility/user needs and the nation as a whole.

Senator DOMENICI. We are searching for ways to move ahead and I think you know that. We may very well have to have a role in that. No question about it.

Mr. Sol Burstein, vice chairman of the Board of Wisconsin Electric Power, we are glad to have you here, sir.

STATEMENT OF SOL BURSTEIN, VICE CHAIRMAN, BOARD OF DIRECTORS, WISCONSIN ELECTRIC POWER CO., ON BEHALF OF THE AMERICAN COMMITTEE ON RADWASTE DISPOSAL; AMERICAN NUCLEAR ENERGY COUNCIL; EDISON ELECTRIC INSTITUTE; ELECTRIC UTILITY COMPANIES' NUCLEAR TRANSPORTATION GROUP; AND UTILITY NUCLEAR WASTE MANAGEMENT GROUP

Mr. BURSTEIN. Thank you, Mr. Chairman. I appreciate your courtesy and indeed your stamina for holding out as long as some of the rest of us are. Obviously, the electric utility industry has a vital stake in the deliberations of your committee and we're glad to have the opportunity to present our full testimony, which as you indicated will be included in the written record of this proceeding.

Senator DOMENICI. That's correct.

Mr. BURSTEIN. You know where we're coming from and where the nuclear portion of our total generation mix has brought us. I think we have heard statements—and let me repeat again today—that the effective implementation of a Nuclear Waste Policy Act is essential for the continued use of nuclear energy in this country. And we are very concerned that we make certain that it does get implemented and that it doesn't get sidetracked.

We also recognize, as you do, that it is our consumer rather than the general taxpayer who's providing the funds for the Nuclear Waste Program. In the current fiscal year, we expect that electric utilities will pay well over $1 billion into the nuclear waste fund.

I think we have five primary matters that we'd like to bring tc your attention. The first has to do with legislated dates in the Waste Policy Act. The specific actions by the Federal Government should be pursued seriously, and any slippage in these dates justified in detail.

This is our primary concern. It's our concern that we wonder whether DOE will be able to meet the 1998 schedule for acceptance of spent fuel. I recall hearing the dates in the act that said "not later than." And then I'm hearing some statements, "We will accept fuel in 1998." And then I hear statements today in this hearing saying, "beginning in 1998." And you had some suggestions made to you that maybe not earlier than 1998, and I think we are very, very concerned that we maintain the schedule.

It's an essential and virtually unprecedented aspect of legislation that this act included the detailed schedules, deadlines mandated by you, for accomplishment of the requirements of the act. And I guess that we know that we've fallen behind in meeting several of the deadlines already. It's imperative that the disciplines provided by these schedules to control the elaborate implementation process be strictly adhered to, and you shouldn't accept any excuses.

Second, we're concerned of course with the funds that are being collected from us and our ratepayers, and that they be spent efficiently and effectively. The Department of Energy's budget for fiscal year 1986, at last for the nonmilitary parts of the Waste Program to which we're addressing ourselves this afternoon, appears reasonable, particularly on the information available to us based on the large increase of activities that go with the start of extensive repository site characterization.

We are concerned, however, that the cost could very easily get out of control without concerted program management and discipline. Obviously, the principal impact on the program cost will be the ability to control the schedule.

You acknowledged earlier that the President has made a recent decision to include defense waste with civilian spent fuel in the first repository. We believe very strongly, and echo the comments made by Mr. Rusche, that the Government must pay its fair share of the cost of the Waste Program in a timely fashion. And these should be based on an equitable sharing of all repository costs, both prospective and prespective.

I mentioned earlier our great concern with the schedule and nuclear fuel acceptance rate. The police act and the contracts we now have between the individual utilities and DOE provide that DOE will begin accepting spent fuel no later than January 31, 1998. We need an overall acceptance rate established that is at least equivalent to the commercial reactor discharge rate in that year. And we need sufficient additional capacity to work off the backlog in a reasonable period of time. Otherwise we're going to have this waste problem hanging around our necks for a considerably lot longer period.

The other item deals with changes to the Nuclear Waste Policy Act. We know that the act, as has been referenced before, has gone a tremendous way toward establishing the confidence of the public and the industry in the country's ability to implement a realistic Nuclear Waste Disposal Program.

Some modifications to the act have already been proposed, including unilateral changes to the waste disposal contracts, separate authorization acts, and other suggestions. We see no demonstrated need to tinker with the act. There has been no basis to suggest that amendments are required at this time. We discourage any approach of a separate authorization act for the program.

And finally, DOE has indicated what its first steps will be toward an MRS proposal. An integrated monitored retrievable storage facility, as part of the overall waste handling system from what we know now, looks reasonable to us. I wish to echo very strongly that in our opinion it should not and could not replace or dilute the need for the geological repository, and if approved by this Congress, the proposed MRS could become that integral part of the final geologic repository program without detracting or diluting the primary mission of the geologic program.

I am sure that we have a lot more that we could say about a number of the other programs that we discussed earlier and that are part of your consideration. In the limits of time that we have, Mr. Chairman, I've confined these comments to the Waste Police Act, and at some other opportunity if you would like, members of the electric utility industry will be glad to and are available to respond to the many other aspects that you may wish to have discussed.

Thank you.

Senator **Domenici**. Thank you very much.

[The prepared statement of Mr. Burstein follows:]

Statement of

SOL BURSTEIN

Vice Chairman of the Board of Directors
Wisconsin Electric Power Company

on behalf of

Edison Electric Institute

American Nuclear Energy Council

Utility Nuclear Waste Management Group

Electric Utility Companies'
Nuclear Transportation Group

and

American Committee on Radwaste Disposal

on

Department of Energy's

Civilian Nuclear Waste Management Program

before

Subcommittee on Energy Research and Development
Committee on Energy and Natural Resources
UNITED STATES SENATE

May 13, 1985

Statement of Sol Burstein

Mr. Chairman and members of the Committee. I am pleased to appear before you today to testify on the Department of Energy's implementation of the Civilian Nuclear Waste Management Program. My name is Sol Burstein, and I am Vice Chairman of Wisconsin Electric Power Company. My testimony is presented on behalf of the Edison Electric Institute (EEI), the American Nuclear Energy Council (ANEC), the Utility Nuclear Waste Management Group (UNWMG), the Electric Utility Companies' Nuclear Transportation Group (NTG), and the American Committee on Radwaste Disposal (ACORD).

Attachment A to this testimony is a copy of a Statement for the Record dated April 3, 1985 to the Senate Appropriations Committee on the Department of Energy Fiscal Year 1986 Civilian Nuclear Budget Request. This attachment covers specific nuclear programs of interest to the electric utility industry; namely, uranium enrichment, commercial nuclear waste, Three Mile Island clean-up activities, breeder reactor research and development, and converter reactor systems research and development. My presentation today will address specific components of the commercial nuclear waste program. Our industry is deeply concerned about this program, and the organizations supporting this testimony are briefly described as follows.

EEI is the national association of investor-owned electric companies. Its members serve approximately seventy-three percent of all ultimate customers in the nation. EEI's membership includes the majority of DOE's nuclear waste services customers.

ANEC represents over 100 organizations having an interest in nuclear energy, including investor, public and cooperatively owned utilities, manufacturers, architect-engineers, and various firms in the nuclear fuel cycle.

UNWMG is a specific activity that is funded by forty-six utilities with nuclear programs, including EEI member companies, public utilities, and cooperatively owned utilities. Its sole objective is to oversee the implementation of the Nuclear Waste Policy Act and to assist in the resolution of spent fuel storage and nuclear waste disposal issues.

NTG represents thirty-seven investor-owned and publicly owned utilities in their efforts to assure that nuclear fuel cycle materials can be transported safely, reliably, and economically. A prime objective is to provide review of, and comment on, DOE's spent fuel transportation activities.

ACORD was formed last summer by nuclear electric utilities. It is a special oversight group composed of eight chief executive officers of public, cooperative, and investor-owned utilities and the Tennessee Valley Authority. ACORD meets periodically to review the nuclear waste program, evaluate utility industry participation, and make our industry's concerns known to the Federal Government.

THE NUCLEAR UTILITY INDUSTRY

Nuclear energy provided nearly fourteen percent of the nation's electricity during 1984, and uranium is now second only to coal as the fuel used for electricity production. Eighty nuclear units were in commercial operation at the start of 1985, with a capacity of 64,932 MWe. Nuclear power plants are now, and will continue to be, necessary to provide the electricity to help drive our economy and maintain it in the future. The effective implementation of the Nuclear Waste Policy Act of 1982 (NWPA) is an essential ingredient for the continued use of nuclear energy in this country.

When considering the civilian nuclear programs of the DOE FY 1986 Budget Request, the revenues projected from electric utilities in FY 1986 will fund over three quarters of the DOE civilian nuclear budget. This includes full funding for the nuclear waste program. The electricity consumer, rather than the general taxpayer, is providing the funds for most of the DOE civilian nuclear efforts. We are, therefore, compelled, in our electricity consumers' interests, to see that these funds are used effectively and efficiently. Additionally, we note that the budget calls for total revenues from the electric utility industry for the nuclear waste management program in FY 1985 and 1986 of $1.5 billion, $622 million more than the projected expenditures.

THE UTILITY INTEREST

The success of the commercial waste program is vital to the continued operation of the nuclear units now in place. There are five primary messages that we wish to convey in this testimony:

1. The legislated dates in the NWPA for specific actions by the Federal Government should be pursued seriously, and any slippage in these dates justified in detail.
2. The funds are to be spent efficiently and effectively.

3. The acceptance rate of spent fuel from utilities should begin as early as practical to achieve a rate that equals, or exceeds, the commercial reactor discharge rate by 1998.
4. There is no justification for any change in, or amendments to, the NWPA at this time.
5. The integrated monitored retrievable storage approach appears to be reasonable and supportable.

As mentioned earlier, the money paid into the Nuclear Waste Fund comes not from government revenues, but from customers of electric utilities. Utilities are now paying into the Fund at the rate of approximately $350 million per year. Annual payments will increase as more nuclear units come on line. In addition, payments for nuclear generation prior to April 7, 1983 will amount to $2.3 billion. In the current fiscal year, it is expected that electric utilities will pay well over one billion dollars into the Nuclear Waste Fund, including payments for current generation and significant portion for prior generation. Utilities are responsible to their electricity customers for seeing that the money is well spent, and the rate regulatory commissions hold utilities accountable for these expenditures. For these reasons we exercise special vigor in overseeing the management of the Nuclear Waste Fund.

SCHEDULE

A primary concern of the utilities regarding implementation of the Nuclear Waste Policy Act is to assure that DOE will meet the 1998 schedule for acceptance of spent fuel. An essential and virtually unprecedented aspect of the Act was the provision of detailed schedules or deadlines mandated by the Congress for accomplishing the specific requirements of the Act by the Federal agencies.

The Nuclear Waste Policy Act establishes a detailed process by which the waste repository site will be selected, licensed, constructed, and operated. It provides considerable opportunity for involvement by the states, Indian tribes, localities, and Federal regulatory bodies. Without discipline, this process can only result in considerable delay. Congress mandated that discipline in the form of deadlines for reaching certain milestones. It is with concern that we note that DOE has fallen behind in meeting these deadlines. DOE was late by a year and a half in promulgating site-selection guidelines. Only a Preliminary Draft of the Project Decision Schedule has been distributed for comment. The final Mission Plan has yet to be sent to Congress. Draft Environmental Assessments were issued only weeks before three sites were to have been recommended for site characterization. EPA has yet to issue final standards. Also, the Presidential site recommendation is now projected to lag by three years the schedule established by Congress.

DOE should be urged to complete quickly the Project Decision Schedule, the Mission Plan, and the Environmental Assessments; and to recommend officially the three sites for site characterization as soon as practical.

COMMERCIAL WASTE PROGRAM COSTS

The Department of Energy's proposed fiscal 1986 budget for programs under the Act appears reasonable-- based upon information currently available. The large increase of seventy-four percent over fiscal 1985 may be appropriate. The Department is starting extensive repository site characterization, an expanded effort in transportation, and development of an integrated system approach that includes an MRS. We intend to follow the program in detail to evaluate whether the funds are being spent efficiently and effectively.

We are concerned that the cost could easily escalate out of control without concerted program management and discipline. Modern business practices should be applied to assure cost control, cash management, appropriate accounting, and reporting. The principal impact on the program cost will be the ability of DOE to control delays in the program.

The electric utility industry concurs with the conclusion of the recent Fee Adequacy Report prepared by DOE that no increase in the one mill per kilowatt-hour fee is required for the time being. We believe that it will be neither necessary nor appropriate to raise the program fee collected from the utilities. Electric utilities will carefully scrutinize any recommendation to raise the fee in the future, and we trust this Subcommittee would do so as well.

The decision has been made by the President to include defense wastes with civilian spent fuel in the first repository. This raises important funding questions. The Government must pay its fair share of the costs of the waste program in a timely fashion. This should include a pay-as-you-go formula akin to the quarterly payments made by the utilities and a matching payment corresponding to the utilities' one-time fee and to fees collected from utilities to date, based on an equitable sharing of the total costs of the repository allocated between commercial and defense wastes. Deferral of defense payments would unfairly require the utilities' financing of non-utility waste activities.

NUCLEAR SPENT FUEL ACCEPTANCE RATE

The Nuclear Waste Policy Act and contracts entered into between DOE and the individual utilities provide that DOE will begin to accept spent fuel for disposal no later than January 1, 1998. The utilities are relying on that statutory mandate and the contractual obligation. The obligation to accept fuel in January 1998 has been recognized by DOE, and a specific acceptance schedule should be incorporated in the contracts. An overall acceptance rate should be established that is at least equivalent to the commercial reactor discharge rate in 1998 and sufficiently above that rate to work off the backlog in a reasonable period of time. The acceptance schedule is the key to the ability of the utilities to keep their nuclear plants in operation. DOE has expressed its view that the utilities deserve the safe disposal of their spent nuclear fuels and a firm planning basis in exchange for the sums of money put into the Waste Fund. We certainly agree.

CHANGES TO THE NUCLEAR WASTE POLICY ACT OF 1982

The Nuclear Waste Policy Act of 1982 went a long way toward establishing the confidence of the public and industry in the country's ability to implement a realistic nuclear waste disposal program. The Act was a landmark achievement, culminating years of effort, with many Congressional committees involved, to develop a firm statutory basis for a successful program. While many individuals would prefer legislation more to their own specific leanings, the NWPA provides appropriate legislation that should not be tinkered with at this time. Some members of Congress have proposed modifications to the NWPA. Some proposals involve parochial political interests that must be resisted. Others propose specific Congressional direction to DOE calling for unilateral amendments to the standard nuclear waste disposal contracts between the utilities and DOE. These proposals call for monthly payments and commercial interest rates that would result in a higher cost to current electricity customers. We fail to see any need for such changes. We believe it is inappropriate for Congress to attempt to rewrite contracts now in effect. In the absence of any compelling need, we urge the Congress to reject any changes to the NWPA.

Including the Nuclear Waste Program Authorization Request within the overall DOE Budget Request each year appears to be appropriate. A separate Authorization Act for the Nuclear Waste Program has been proposed. Such procedure presents the temptation and opportunity to make substantive changes in the NWPA without effective review by responsible committees of Congress. We recommend against development of a separate Authorization Act for the Nuclear Waste Program.

MONITORED RETRIEVABLE STORAGE (MRS)

DOE has also taken the first steps toward a proposal to be submitted to Congress for a Monitored Retrievable Storage facility, as required by the Nuclear Waste Policy Act. As you know, three sites were announced on April 25, 1985 as candidate sites by DOE. The Department has selected two alternative design concepts and initiated design work. If the MRS facility is approved by Congress, it may become an integral part of the final geological repository program. The MRS neither replaces a geological repository nor detracts from the need for one.

DOE's recent concept of an integrated MRS as part of an overall waste-handling system seems reasonable. The Department is considering the use of an integrated MRS as a facility to receive and package spent fuel in preparation for final disposal in a geological repository. This arrangement could contribute to overall efficiency, particularly if it permits reduction in shipment-miles as spent fuel travels from reactors to repository and simplifies the repository licensing considerations. We are studying the documents released by DOE on April 25 with regard to the integrated MRS program. Utilities will provide.comments to DOE on these documents.

CONCLUSION

The utilities look to the members of this Subcommittee to provide guidance to DOE to ensure the timely, cost-effective implementation of the Nuclear Waste Policy Act. The NWPA provided a mandate, a road map of procedures, and a schedule for accomplishing permanent disposal of nuclear wastes in geologic repositories. DOE's program has been, and will continue to be, subject to attack and opportunities for delay. While we do not believe amendments to the Act are desirable at this time, continued direction from Congress clearly is needed. The utilities are obligated to see that the nuclear waste program proceeds in a responsible manner and that our customers, who are paying for the program, get their money's worth.

DOE is involved in a number of vital programs that are needed for the proper use of the nuclear option in meeting the nation's energy supply needs. The Nuclear Waste Program is one of the more important programs, and DOE must implement this program as a vital business activity, along with the other civilian nuclear programs, in an effective and efficient manner. This Subcommittee plays a major role in assuring that this is accomplished.

Thank you for the opportunity to present the view of DOE's nuclear service customers.

Attachment

ATTACHMENT A

STATEMENT FOR THE RECORD
BY
EDISON ELECTRIC INSTITUTE
AMERICAN NUCLEAR ENERGY COUNCIL
AND
THE UTILITY NUCLEAR WASTE MANAGEMENT GROUP
SUBMITTED TO
SUBCOMMITTEE ON ENERGY AND WATER DEVELOPMENT
COMMITTEE ON APPROPRIATIONS
UNITED STATES SENATE
ON
DEPARTMENT OF ENERGY FISCAL YEAR 1986
CIVILIAN NUCLEAR BUDGET REQUEST
APRIL 3, 1985

The Edison Electric Institute (EEI), the American Nuclear Energy Council (ANEC), and the Utility Nuclear Waste Management Group (UNWMG) appreciate this opportunity to submit a statement for the record regarding the Department of Energy (DOE) Fiscal Year 1986 civilian nuclear budget request.

EEI is the national association of investor-owned electric companies. Its members serve approximately 73 percent of all ultimate customers in the nation. EEI's membership includes the majority of DOE's domestic uranium enrichment services customers as well as DOE's nuclear waste services customers.

ANEC represents over 100 organizations having an interest in nuclear power, including investor, public and cooperatively-owned utilities, manufacturers, architect-engineers, and various firms in the nuclear fuel cycle.

UNWMG is a specific activity that is funded by forty-six utilities with nuclear programs, including EEI member companies, public utilities, and cooperatively-owned utilities. Its sole objective is to oversee the implementation of the Nuclear Waste Policy Act and to assist in the resolution of spent fuel storage and nuclear waste disposal issues.

Nuclear energy provided nearly 14 percent of the nation's electricity during 1984 and uranium is now second only to coal as the fuel used for electricity production. Eighty nuclear units were in commercial operation at the start of 1985 with a capacity of 64,932 MWe. Nuclear power plants are and will continue to be necessary to provide the electricity to help drive our economy and maintain it in the future. Additionally, nuclear power plants have saved billions of dollars for the nation's electricity consumers through savings in fuel costs by, primarily, displacing foreign oil.

The DOE FY 1986 Budget Request is $12.5 billion. When looking at the civilian nuclear programs alone, the revenues projected from electric utilities in FY 1986 will fund over three quarters of the DOE civilian nuclear budget. This includes full funding for the nuclear waste and uranium enrichment programs. Thus, the electricity consumer, rather than the general taxpayer, is providing the funds for most of the DOE civilian nuclear efforts. Therefore, we are compelled to protect our electricity consumers' interests by seeing that these funds are used effectively and efficiently. Additionally, we note that the budget calls for total revenues from the electric utility industry for the nuclear waste management program in FY 1985 and 1986 of $1.5 billion, $622 million more than the expenditures.

DOE'S URANIUM ENRICHMENT PROGRAM

What makes nuclear energy economically desirable is its very low fuel cost as compared with other generation technologies. An indispensable part of the nuclear fuel cycle for our current reactors is uranium enrichment. A reliable source of competitively priced enrichment is necessary for nuclear energy to retain its economic advantage. DOE has always been the primary supplier of these services. However, foreign suppliers are now at our door offering very attractive contracts. In the interests of our electricity customers, we must buy these services at the lowest practical cost from a reliable supplier.

From September 1973 until January 18, 1984, the only contracts offered were take-or-pay arrangements that required enrichment customers to make firm commitments for an extended period and to take delivery of the service whether it was needed or not. This resulted in the building of costly inventories of enriched uranium that produced an untenable situation that upset the fundamental balance between supply and demand for enrichment services as nuclear units experienced delays or were cancelled. Enrichment service purchasers and suppliers, foreign and domestic, were faced with a chaotic market situation with utilities becoming major sellers on the secondary market.

DOE responded to the situation by offering the Utility Services (US) Contracts. The US contracts were offered after a two year effort, which included a public comment period, to develop workable, mutually compatible, competitive, market-oriented contractual arrangements. As DOE has indicated, the US contracts conversion effort has captured about 90 percent of its previously contracted business. The new contract permits DOE to be a competitive supplier. But to remain competitive, DOE must proceed cautiously and wisely, in a sound business manner, in the selection and deployment of a more efficient enrichment technology.

DOE appears to have struck a delicate working balance among the conflicting objectives that it faces. The US contracts are a major part of DOE's strategy to manage its enrichment program more effectively. They are a fair compromise between the customers' needs, DOE's constraints and foreign competitive offerings. They provide the utilities with assurance of supply, added flexibility in dealing with over-stocked inventories, and an opportunity to keep costs to consumers reasonable.

DOE must bring on future enrichment technology to contain the ever rising cost of uranium enrichment. Regardless of what DOE is able to do in the near term on cost control and business-like practices to reduce the SWU price, the high cost of production by the current technology will ultimately prevent DOE from meeting its competition and fulfilling its promise to its customers. If it does not, greater numbers of current customers will find refuge in the secondary market and, eventually, with foreign producers.

Both of the advanced uranium enrichment technologies appear to have advantages over the gaseous diffusion process from the customer's standpoint. DOE has indicated that it will make a technology choice in May 1985. Our interest in this decision is to be certain that the choice is made in a manner consistent with the best interests of those to be served by the decision -- our electricity consumers. We firmly believe that the decision should be made in May and not delayed for any reason. It is not a decision to deploy, on a commercial basis, a specific new enrichment facility. The decision to deploy will be made later and will be based on a better understanding of enrichment economics and capacity needs. We endorse this approach. We support the continuation of the Gas Centrifuge Enrichment Plant (GCEP) if the enrichment program strategy developed as a result of the technology selection shows it to be appropriate.

Last year, the DOE FY 1985 Budget Request indicated that the size and scope of DOE's new enrichment technology program will be driven by the market response to the new contract and attendant revenues. We endorsed this approach and are most pleased to see that DOE is following through on its promise. DOE indicates that it is proceeding on a schedule to select a preferred technology in May of this year. A number of business decisions will be made based on this selection.

DOE has identified in its Budget Request the potential need to find alternative sources of financing to continue the work necessary to insure the timely availability of the lower cost future technology. Some innovative opportunities for financing the development of the new technologies may be necessary if net appropriations are not forthcoming in any year that they may be requested in the future. However, one thing is clear: Electricity customer funds are not sufficient to continue the development of two advanced technologies at the pace and funding level they are being pursued during the current selection process. That is one reason why a decision is needed now.

While external financing is one means of providing the funds for future construction and development, there are other sources of cash within the DOE enrichment program that should be fully explored. DOE appears to be vigorously exploring cost reduction alternatives, including the retirement of facilities not necessary to meet its contract obligations and operational cost savings. We urge DOE to continue to explore ways to economize within the enrichment enterprise as any efficient business must to serve its customers properly.

On a related funding matter, DOE indicated that it will start paying back the Treasury for the Government's investment in uranium enrichment. At this point we are uncertain what this entails. However, we will be watching closely to see that the electricity customer is not charged more than once for any investment the Government has made. We are most interested in the basis that will be used for determining the applicable pay back, especially considering that the facilities were originally constructed for military purposes and much of the funds for modifications were provided from customer fees paid for enrichment services.

It is clear that DOE is responding to its customers and taking some bold steps to improve its market position, to lower future costs, and to remain a reliable, competitive supplier of enrichment services. DOE, through the new US contracts has made a commitment that recognizes the industry's needs. We support DOE in this regard. Also, we fully support the need for the

United States to continue to be a major supplier of enrichment services for the world and to do so on a basis that provides an assured, long-term supply capability at the lowest practical cost that is competitive with the other suppliers. This is in the best interest of the nuclear utilities and their customers and, because of the positive effects on our foreign trade balance, the nation.

DOE COMMERCIAL WASTE PROGRAM

Utility Oversight

The utilities are closely following the implementation of the Nuclear Waste Policy Act for several reasons.

First, as mentioned above, the money paid into the Nuclear Waste Fund comes not from government revenues but from customers of electric utilities. Utilities are now paying into the Fund at the rate of approximately $350 million per year. Annual payments will increase as more nuclear units come on line. In addition, payments for past nuclear generation will amount to $2.3 billion. In the current Fiscal Year, it is expected that electric utilities will pay well over one billion dollars into the Nuclear Waste Fund. Utilities are responsible to their electricity customers for seeing that the money is well spent, and the rate regulatory commissions hold utilities accountable for these expenditures. For that reason, we exercise special vigor in overseeing the management of the Nuclear Waste Fund.

Second, the success of the commercial waste program is vital to the continued operation of the nuclear units now in place. It is vitally important that the nation's reactors continue to operate, but if any reactor reaches a point where the utility cannot ship its spent fuel or store it on site, the unit must shut down. Loss of operating nuclear units would certainly drive up electric rates and could have damaging effects on the utilities' ability to provide for reliable service and on the economy, in general.

Third, the Nuclear Waste Policy Act and contracts entered into between DOE and the individual utilities provide that DOE will begin to accept spent fuel for disposal no later than January 1, 1998. The utilities are relying on that statutory mandate and the contractual obligation. This obligation is recognized by DOE and a specific acceptance schedule should be incorporated in the contracts.

Fourth, continued progress toward resolving the nuclear waste issue is one of the important prerequisites that must be realized before nuclear energy will again be relied upon for meeting future electrical generation needs.

Commercial Waste Program Costs

The Department of Energy's proposed fiscal 1986 budget for programs under the Act appears reasonable -- based upon information currently available. The large increase of 74 percent over fiscal 1985 may be appropriate because of DOE's large programmed expenditures. The Department is starting extensive repository site characterization, an expanded effort in transportation, and development of an integrated system approach that includes an MRS. We intend to follow the program in detail to evaluate whether the funds are being spent efficiently and effectively.

We are concerned that the cost could easily escalate out of control without concerted program management and discipline. Modern business practices should be adopted to assure cost control, cash management, appropriate accounting and reporting. The principal impact on the program cost will be the ability of DOE to control delays in the program.

Waste Fund Revenues

The electric utility industry concurs with the conclusion of the recent Fee Adequacy Report prepared by DOE that no increase in the one mill per kilowatt-hour fee is required for the time being. We believe that it will be neither necessary nor appropriate to raise the program fee collected from the utilities. In this regard, we are encouraged by Mr. Ben Rusche's commitment to implement the Nuclear Waste Policy Act within the projected revenues of the one mill per kilowatt-hour user's fee. Electric utilities will carefully scrutinize any recommendation to raise the fee in the future, and we trust this Subcommittee would do so as well.

If defense wastes are included in the repository -- and the President is to make that decision soon -- the Government must pay its fair share of the costs of the waste program in a timely fashion. This should include a pay-as-you-go formula akin to the quarterly payments made by utilities; and a matching payment corresponding to the utilities' one-time fee, and to fees collected from utilities to date -- based on the percent of the repository allocated to defense wastes. Deferral of defense payments would be inconsistent with Section 8 of the Nuclear Waste Policy Act and would place an undue burden on the utilities' contribution to the Waste Fund.

Schedule

A primary concern of the utilities regarding implementation of the Nuclear Waste Policy Act is to assure that DOE will meet the 1998 schedule for acceptance of spent fuel. The Nuclear Waste Policy Act reflects Congress' strong interest in meeting the schedules set forth in the Act. An essential and virtually unprecedented aspect of the Act was the provision of detailed schedules or deadlines mandated by the Congress for accomplishment of the requirements of the Act by the federal agencies.

Congressional committees carefully considered the testimony of witnesses from DOE, NRC and other federal agencies and interested parties before reporting draft legislation. Based on such testimony, the schedules originally established in draft bills were adjusted to provide three additional years to be allocated to site identification, site characterization and selection, and to NRC's review and approval of the application to build the first repository. The Senate Committees determined the schedule to be "realistic and workable" and expected "the involved agencies to do everything possible to assure that [the] schedule is met." 1/ Indeed the statutory deadlines were extended even further after careful consideration by the House Committees and recommendation by the Senate.

The Nuclear Waste Policy Act establishes a detailed process by which the waste repository site will be selected, licensed, constructed and operated. It provides considerable opportunity for involvement by the States, Indian tribes, localities, and Federal regulatory bodies. Without discipline, this process can only result in considerable delay. Congress mandated that discipline in the form of deadlines for reaching certain milestones. It is with concern that we note that DOE has fallen behind in meeting the deadlines specified in the Act. DOE was late by a year and a half in promulgating site selection guidelines. Only a Preliminary Draft of the Project Decision Schedule has been distributed for comment. The final Mission Plan has yet to be sent to Congress. Draft Environmental Assessments were issued only weeks before three sites were to have been recommended for site characterization. EPA has yet to issue final standards. The Presidential site recommendation is now projected to lag by three years the schedule established by Congress.

DOE should be urged to complete quickly the Project Decision Schedule, the Mission Plan and the Environmental Assessments;

1/ S. Rep. No. 282, 97th Cong., 1st Sess., 21 (1981).

and to recommend officially the three sites for site characterization as soon as practical.

Monitored Retrievable Storage (MRS)

DOE has also taken the first steps toward a proposal to be submitted to Congress for a Monitored Retrievable Storage facility, as required by the Nuclear Waste Policy Act. The Department has selected two alternative design concepts and initiated design work. If the MRS facility is approved by Congress, it may become an integral part of the final geological repository program. The MRS neither replaces a geological repository nor detracts from the need for one.

DOE's recent concept of MRS as part of an integrated waste handling system seems sensible. The Department is considering the use of an MRS as a facility to receive and package spent fuel in preparation for final disposal in a geological repository. This arrangement could contribute to efficiency, particularly if it permits reduction in shipment-miles as spent fuel travels from reactors to repository.

The utilities look to the members of this Subcommittee to provide oversight necessary to ensure the timely, cost-effective implementation of the Nuclear Waste Policy Act. The NWPA provided a mandate, a roadmap of procedures and a schedule for accomplishing permanent disposal of nuclear wastes in geologic repositories. DOE's program has been and will continue to be subject to attack and opportunities for delay. While we do not believe amendments to the Act are necessary, continued direction from Congress clearly is needed. The utilities are obligated to see that the nuclear waste program proceeds in a responsible manner and that our customers, who are paying for the program, get their money's worth. We ask your assistance in this endeavor.

Three Mile Island Activities

The clean-up of TMI-2 must and will be accomplished. It is another necessary element for the future growth of the nuclear energy option.

The investor-owned electric utility industry will provide $25 million toward the cleanup each year for a period of six years, providing a total of $150 million. Our program began this year in accordance with a Resolution passed by the Edison Electric Institute Board of Directors on June 18, 1984.

An initial payment of $9 million was made to the General Public Utilities Trust Fund on December 28, 1984. Additional funds, up to $25 million, will be provided during 1985. Twenty-five million dollars will be provided each year from 1986 through 1990. A substantial portion of these funds is being provided on a voluntary basis from a broad range of EEI member companies. A supplemental portion, to maintain a funding level of $25 million each year, is being provided as research and development grants from a number of Pennsylvania and New Jersey utility companies.

Funding today is not a limiting element on the progress of TMI-2 cleanup, in part because of the continued Federal support and the newly assured industry support. This allows the work to proceed with an estimated expenditure of $120 million during

1985. Continuation of Federal R&D support funding, in addition to the industry funding, is vitally important to the cleanup program on the current schedule and assuring that the maximum of R&D information is obtained.

Federal funds have been committed during the past few years to support the research and development efforts related to the cleanup activities. Results from this Federal commitment have been substantial, and we urge the commitment be continued for several more years. The knowledge obtained from the research and development is useful in many ways in providing a better understanding of the details of nuclear plant design, operation and decommissioning.

Breeder Reactor Systems Research and Development

Breeder reactors continue to represent the best apparent technology to satisfy the long-term need of assured electricity supply that can be available for many centuries. Earlier projections of when this technology would be needed were overly optimistic and there is time to pursue the important matters that will permit this technology to be used efficiently. The DOE breeder program should be directed toward those research and development programs that have the greatest potential payoff. Funds should be made available and concentrated on those tasks that will expand our technological base on breeder reactors and the accompanying fuel cycle.

Converter Reactor Systems Research and Development

Light-water reactors being used successfully to produce electricity are converter reactors. The continued use of these reactors is vital to the financial health of the nation. Programs are needed to overcome the unnecessarily burdensome institutional, financial, technical, and regulatory barriers in this area. Also, many utilities continue to support the High Temperature Gas Reactor (HTGR) concept and believe that it should be pursued as a reasonable alternative technology to today's light-water reactors. These utilities support the development of HTGR technology both financially and with managerial expertise through the Gas Cooled Reactor Associates (GCRA). Continued government cooperation and financial support are vital to the success of the joint effort now underway to determine if the HTGR will be sufficiently attractive to achieve commercial acceptability.

CONCLUSION

DOE is involved in a number of vital programs that are needed for the proper use of the nuclear option in meeting the Nation's energy supply needs. In two large programs, uranium enrichment and nuclear waste, the electric utility companies supply all the funds for DOE expenditures. DOE must conduct these two programs as vital business activities, along with the other civilian nuclear programs, in an effective and efficient manner. This Subcommittee does play a major role in assuring that this is accomplished.

By the year 2000, America is likely to need at least 100 to 200 million kilowatts of additional generating capacity beyond those plants either in place or under construction. In February 1985, the Report of the Edison Electric Institute on Nuclear Power was released. It indicates that a number of changes must be made if nuclear energy is to be available as an option in the future. If changes are not made, both in industry and government, we will not have a growing nuclear energy program. A business-like, competitive uranium enrichment program, a permanent disposal system for nuclear waste and a successfully cleaned-up TMI-2 are three of the necessary elements for nuclear energy to grow in the future.

Thank you for the opportunity to present the view of DOE's nuclear service customers.

* * * * * * * * * *

Senator DOMENICI. Obviously, to some extent, you are all aware of the fact that as far as these two Senators that are here—I am sure I can speak for my good friend, the chairman of the committee—in a sense when it comes to the future of nuclear energy and how we've gone astray and what we will live to regret in terms of not using it as much as we should as a nation, you're preaching to the choir.

But I do believe, before I ask just a few questions, that there is a growing proper information out there and knowledge about nuclear energy that wasn't here 10 years ago. I'm sorry it occurred at that point in time; coupled with the financing problems of high interest rates and long-term financing, it hit the industry at exactly the wrong time.

But I think there is a growing concern about the other kinds of energy and there are safety and pollution and environmental problems that at least puts it into perspective.

And I'm hopeful that we can do the things we must to set it right again and move it on the right track.

Let me just say that while I'm worried about the whole industry and why the United States, which was the premiere country in the world in this field is now taking a back seat to a couple, I'm also worried about the fact that we're not going to have a uranium industry pretty soon, and I compliment you for your testimony, Mr. Farley. I think it was excellent. We will look over all the suggestions.

I think I from time to time, because my State is the—was the premier uranium-producing State in the country, I've tried almost every one. I haven't tried the domestic—that aspect that requires that we use domestic as you stated. But all the others I've tried. I'm somewhat surprised by the Secretary saying he won't have the viability reports ready and we'll check that out.

But let me ask you, if I read the DOE correctly, Mr. Farley, they say the uranium industry will start up again in this country when the price goes up. Is it that simple?

Mr. FARLEY. No; it's not that simple at all, Senator. Price is only one factor. Practically all of us are shut down now. Some mines have been permitted to be flooded. In my judgment, very few of those who have already gone out of the industry will ever come back, and I don't they will be induced by increased price.

There are only a handful of us; there is only a handful of us, numbering perhaps six companies, who are willing to consider trying to tough it out and some of us won't last very long if we don't get some help. It's not just price. It's the loss of our facilities. We've lost our major staffs. Our miners have gone. People have disappeared. It's not going to be easy to revive.

Senator DOMENICI. I was just telling my friend, Senator McClure, that it is really historic when a State like New Mexico, which at one point was producing 75 percent, from the beginning was the largest producer, I guess it was just last month or the month before that, that we became a State without an active uranium mine for the first time since the Atomic Radiation Commission.

Mr. FARLEY. That's the current status.

Senator DOMENICI. And I think if you would permit me to ask you about the Mount Taylor mine in my State, I'm not sure if you're totally familiar with it, but it's one-quarter of the entire U.S. proven reserves. In order to keep it from flooding, pumps are running all the time. I understand if they weren't, it would flood in about 20 minutes if you shut them off.

If this mine were abandoned right now, since it's not producing, and totally abandoned consistent with the attitude that it'll be all right when the price goes up, I might ask could you just pump it out and start over again?

Mr. **Farley**. No. I think it's lost. I think it would be lost. And, Senator, you must realize, as I'm sure you do in that connection, that sooner or later, even those who are left or want to remain in the industry and want to tough it out and come back with it, have to look at the cost of money. We have to look at maintenance expenses, how long they're going to last, and if it looks like no relief is going to be forthcoming to this industry by the end of this calendar year—to pick a date—I would suspect that we will probably all choose to forget it.

Senator **Domenici**. Well, I'm just wondering, with reference to that large, large mine which is very deep an very, very costly—I remember when they first started. It's a magnificent mine; it's way down underground, but it tapped the seam that 10, 12 miles away was the rich one; it just happes to be underground at this point. That's why they were willing to spend all the money. I'm not sure that your statement is correct, that it could not be just pumped out.

But it does sound right, because if not, why wouldn't they stop? They have any—just stop pumping it now. But is this technical information you're giving me, or just your assumption?

Mr. **Farley**. No. I don't know intimately the Mount Taylor mine. I haven't been involved in New Mexico uranium since we were part of the Home Stake New Mexico Partners Group originally. But I am merely disclosing a perception I have from industry conversation. But I don't know that. Mount Taylor may come back, but all I do know is that when you permit a mine to flood, it isn't a very good sign.

Senator **Domenici**. I would like to ask you one more question, and then Mr. Burstein, and then I'll yield to Senator McClure.

With reference to the present live tailing sites which we are going to have to start cleaning up, we have a bill that you're aware of—Senator Bingaman, myself, Senator Wallop—did you state that in the negotiations with the Atomic Energy Commission, going back a number of years, that the various expenses and costs attributable were discussed, but never was it discussed that you would have to clean those tailings up as presently required, or soon to be required by law?

I think it's very relevant that you give us this, because we have to have the DOE pay for part of this, and one of our assumptions is they created it because they were the contractors for a big portion of it, and I think some may answer it was assumed as part of the cost. I've never heard that it was.

Mr. **Farley**. During the major duration of the Atomic Energy Commission buying program—and I include mainly the mill-buying program of U-308—the heart of it was that we, the producers, would receive compensation based on our direct costs, some allowance for G&A, depreciation of our facilities, and a small profit factor or amount.

At no time in any of those negotiations was there ever any discussion, to the best of my recollection, of any danger of tailings piles, and absolutely at no time was there ever any consideration of the cost of doing something about stabilizing those piles or decommissioning the mills and therefore there was never any allowance built into the formula for reimbursement for those.

Senator DOMENICI. Thank you very much.

Mr. Burstein, you indicated that you'd be willing to contribute some additional information since you focused mostly on the permanent waste disposal policy and process. Are you familiar with Senate bill 1004, the remedial cleanup bill that's being suggested by the distinguished Senator from Wyoming, myself, and Senator Bingaman?

Mr. BURSTEIN. I think I have a preliminary draft. I'm not sure that's the correct number, but——

Senator DOMENICI. I don't want to ask you at this point your views, but could I ask you this: Would you, in the near future, since we'll be having to talk with your industry again, would you peruse that and get some opinions for us and let us talk informally before we have the formal joint hearings? We intend to have joint hearings with the House. I think it's an excellent approach. Both houses have the same bill; both committees seem to have the same goal, and we're going to experiment. Why have two sets of hearings?

Mr. BURSTEIN. I commend you for that economy for all of our time. I think we all share the frustration and disappointment with the previous legislation or the success of it in respect to mill tailings cleanup. We'll be glad to address the future of this bill and report when the appropriate time comes.

Senator DOMENICI. Thank you very much.

Senator McClure.

The CHAIRMAN. Thank you very much, Mr. Chairman, and I want to thank each of the witnesses for your stamina and your willingness to sit with us through a long afternoon in order to give us the advantage of your perspective and the wisdom of your advice to us. I personally appreciate it, and hope all members of Congress don't take for granted the fact that you come and sit for hours in order to have a chance to tell us something.

And I think sometimes we don't give you credit for your willingness to do that. I don't want to pass the opportunity to commend you for your willingness this afternoon.

Mr. Boyer, looking toward the possibility of a prototype testing of an HTGR, what kind of financial commitments or financial arrangements are envisioned for the establishment of such a prototype testing?

Mr. BOYER. Well, that's still being explored. It could work out that a utility would be involved, or it could work out that it would have to be, since it's a test facility, to be supported basically by Government funding.

The CHAIRMAN. Excuse me. Let me rephrase that. How much money would be required of DOE to complete such a prototype test program? Or perhaps I could say what would be the total cost, and then explore what industry might be able to contribute.

Mr. Boyer. Yes. I don't have those figures directly in front——

The Chairman. Could you provide for the record your estimate?

Mr. Boyer. I could provide that to you; yes. Since it's a small modular unit, it doesn't amount to as much as one would first think for a demonstration of a facility, and it's just the nuclear portion which we would be testing. I'll get those figures for you, though.

The Chairman. I understand that, but I think essential to any discussion of what our likely success may be needs to envision the total cost of the financial commitment by the Government to such a project, and the willingness of people on the other side to contribute as well.

Obviously, the higher the contribution by nongovernmental sources, the quicker we can get it worked into the budget. If you could come up with 99 percent of the money, I'll guarantee you we'll get the other done next year. Scale it down a little bit. If you expect Government to put up 99 percent of the money, it may be 99 years before we get it in the budget.

Now, I speak in graphic terms, not intended to be accurate terms, but certainly there is some——

Mr. Burstein. We appreciate the reality of the situation.

The Chairman. It's a question, under current budgetary considerations, a very difficult one for us to assure a rapid budgetary decision in light of the fact that even with the magnificent action taken by the Budget Committee in the Senate last week—and I want to give our current chairman now presiding here full credit for the results of a $50 billion—$56 billion deficit reduction in the first year, and a nearly $300 billion reduction over a period of 3 years, with I think a projected performance, if every element of that were kept in place for 5 years, we would reach a balanced budget in 5 years. That nevertheless means it's 5 years from now before we get to a balanced budget, with no increases in expenditure in any elements of the budget that we now envision.

Senator Domenici. And tremendous economics for the whole 5 years.

The Chairman. And very good economics for 5 years. So we have at least a 5-year waiting period before we can see a very large reduction in the pressures on the budget. And you're telling us you want us to get at it now. And I understand that. I want us to get at it now, too, and the budget doesn't reflect my own sense of priorities, but it does reflect the collective sense of priorities within the Senate.

So we're going to do the best we can. All I am suggesting is that maybe it's going to take more than just the best we can.

Mr. Burstein. Senator, if I may.

The Chairman. Yes, Mr. Burstein.

Mr. Burstein. I want to add the applause of some of the private citizenry in this chamber to our gratitudes to our chairman for the work he did on that massive budget program last week. We appreciate it very much.

As you know, we are very much concerned with our abilities to be able to fund many of these much-needed demonstration programs, whether it be in areas of nuclear power or as you will hear in a few days, on acid rain, or a few other matters where we are being asked to develop technologies and programs.

We may not be able to convince our own State regulators and those at the Federal level having to do with our rate structures as to the wisdom of having current rate payers pay for a future benefit. I think this is a very serious matter that compels us to seek the kind of general support that you've heard some of us mention before you today. It is for the reasons that we find our own abilities to raise these funds virtually cut off because of the pressure on current economic needs, that we find ourselves unable in many cases to do those things that we believe very firmly should be done.

The Chairman. I understand that, and I don't mean to be at all critical of the lack of effort. I'm sure, as you know, there are many of us who think that the utility problems in this country are far larger than just nuclear problems or, to phrase it another way, we don't have just a nuclear question; we have a much more fundamental question addressing the utility industry in this country. And the full Committee on Energy and Natural Resources will either itself, or through one of the subcommittees, hold hearings on that later this year, because I believe it's absolutely essential for us to address those rather fundamental problems.

I note on page 15 of the attachment to your statement, you're looking—identifying some of the more general problems facing the nuclear industry, and you refer in your conclusion, near the bottom of the page, that by the year 2000 America is likely to need at least 100 to 200 million kilowatts of additional generating capacity. That's beyond those plants either in place or under construction. That's additional capacity.

Now, let's assume for a moment that the downsizing is accomplished and we cut current plants in one-half and we're not building 1,000 megawatt plants; we build them in 500 megawatts, which, you know, there's a lot of discussion. That's as good a base point for discussion as any other.

And let's assume that the nuclear industry provides one-half those plants, and let's assume that we immediately, this year, cut the licensing time to 6 years so you can start in building plants, get some on line starting 6 years from now—that would be 1991 or 2. And you've got about 9 years left in which to meet that target you've established.

And just the limited portion I'm talking about in nuclear plants would require that you put two new plants on line each month. Do you really think that's possible? Well, it certainly isn't possible now.

Mr. Burstein. I think it is possible. The dynamics, the strength of this country economically, from its capability and competence of its workforce and the dedication to a purpose, certainly. In terms of whether it is institutionally possible or economically possible under the current uncertainties that face our industry, I think you have raised a very significant concern that we all have. I don't think so.

The Chairman. I agree with your statement completely. If there were no constraints on our ability to do it, the technological/industrial community could build those plants. But the rest of the story isn't included in that "if," and the rest of the story tells you and tell me, no, we can't; which means that unless something changed very drastically in this country, we're not going to meet our power needs in the year 2000—at least as outlined by you.

Now, that's a bald statement. And I hope it's provocative enough that some people around here will start listening. You and I have to raise our voices, I guess. Maybe we should start a demonstration in front of DOE and have demonstrators arrested on a daily basis. We would then get some headlines and we'd change policy, because then everybody would understand that it's an important policy that we're directing our attention to.

That seems to be the way in which news is created, attention is drawn, and to which policymakers then respond. Short of that, we don't seem to be able to focus our attention on anything. I have often said this Nation has the attention span of a 3-year-old.

Senator DOMENICI. I have a 3-year-old grandson that has better attention. My 3-year-old grandson.

The CHAIRMAN. Well, I understand your 3-year-old grandson is an exceptional child.

Senator DOMENICI. By definition.

The CHAIRMAN. By definition, all grandchildren are.

Senator DOMENICI. That's right. That's what I meant.

Senator McClure, I think you're absolutely right, and I don't think what you're saying is limited to constructing electrical generating plants. I would share with you and people here, we're going to have the Superfund within a month or two. I don't think there is any question that you could take a cross section of American industry that's involved in cleaning up a hazardous dump, set them in a room with all their talent, capacity to do things, and ask them how long would it take to clean up 3, 4, 500, 600, whatever they want, and I am sure that American industry, all combined, would say 3 or 4 years, we could do it.

I can tell you right now that because we are involved in a statute that nobody understands, we're about to end up in the position where no one will write liability insurance for those who are going to do the work. That's one of the institutional things.

Now, I am just sure that that same group, if you asked them to put up their hand, you say will you do it, you can't get liability insurance to cover your business, I'm sure they will all walk out of the room. It's the same kind of thing we're talking about here. We can produce them if the institution, principally Government, would just find a way to permit them to do the work.

The way we've been doing it, your schedule will never be met. You can answer that right now. There's no way we can build two of these a month for the last 7 years of this decade.

The CHAIRMAN. Last 9 years.

Senator DOMENICI. Last 9 years.

The CHAIRMAN. Last 9 years of this decade. That's what it would take to meet half the load.

Senator DOMENICI. Pretty soon we're going to find we shouldn't be using coal. Then we'll have neither. Don't you think pretty soon they're going to find out it's not so safe, too?

The CHAIRMAN. Well, I think there is no question that the growing concern over atmospheric results of the combustion of large quantities of fossil fuels is narrowing the opportunities for that alternative in the future.

Senator DOMENICI. That isn't acid rain.

The CHAIRMAN. That's a part of the issue, not all of the issue. The reason I mention that is just two things.

It seems to me, Mr. Burstein, that the EEI report on Nuclear Power which was released in February focused on a lot of the problems and made some valuable criticisms and pointed us in the direction of some solutions.

But I wonder if you could supplement that report either by formal action of EEI or otherwise, to tell us what the answers to many of those questions are. You point to institutional, financial, technical, and regulatory changes that must be made. And that's perhaps a bigger order than we're prepared to answer this afternoon, but we're going to get back to that question, and I hope EEI will be ready to give us some assistance as we look at specific questions and specific suggestions of actions that can be taken and must be taken by governments in order to allow the people in the private sector to do the job that you're so magnificently able to do if we'd just let you.

Mr. BURSTEIN. The industry is going to be prepared to respond at your invitation.

The CHAIRMAN. Thank you very much.

I guess I would, just by way of parenthetical explosion, if that's a proper way to state it, I just wonder if we're not at the point in our Government where we're finding out whether or not we can survive with all the checks and balances on the system that we have installed.

The transference of discretionary judgments to courts, as an example; the opening up of the court processes to private lawsuits, individual lawsuits, without any necessity for standing having first been demonstrated, as was the case before; intervenor funding of lawsuits; the cross lawsuits of one agency of Government to another agency of Government having been added to all of the rest of the checks and balances that were inherent in our Constitution, which has led to what has been described as paralysis by analysis, and a lot of other epithets heaped on it.

But I just wonder if we are not at the point where we better ask ourselves a rather fundamental question of whether we have so detracted from our ability to make decisions that we can no longer compete in our societies across the world. And I feel that we may be at the point where, if we don't address some of those questions rather fundamentally, we're going to be asking the wrong questions and coming up with only some very partial solutions.

Mr. FARLEY. Senator, some of us in the private sector have been asking those questions of ourselves for quite a while now.

The CHAIRMAN. But you need to ask it again, maybe by protesting in front of the Supreme Court building. You know, the Supreme Court like all of this openness and they criticize everybody else for cutting off the people's rights to access. Maybe you need to invade their chambers with masses of people from time to time to remind them that there is another side to that question.

They operate in detached splendor and don't seem to understand that others can't quite function when you can't get through the front door of your building because of protesters. They get their paycheck on a monthly basis and don't seem to understand that others don't function quite so well when your capacity to get your job done threatens the company's financial integrity and the ability to pay its employees, let alone provide its services.

And I know that utilities privately will say—some, not all certainly—but some will say it just isn't worth the struggle anymore; let's only ride along with the current until we retire.

Well, I would suggest utility executives who feel that way are human beings responding to very difficult circumstances, but they better be looking at their life expectancy tables and wondering whether or not they're going to be able to draw that pension during the rest of their life.

Mr. Burstein. You'll notice there are one or two old grey-haired among us who are still fighting.

The Chairman. Yes, sir. And I am grateful for that, and I suspect I'm preaching to the choir, too. I notice a notable departure from the press table. We passed all the daily deadlines, so I know I'm just talking for the fun of it.

Maybe I feel better.

Senator Domenici. But it is fun in any event, isn't it? [Laughter.]

The Chairman. And I apologize for infringing on your time. I'm enjoying it more than anybody else is, I suspect. But I'm frustrated, and I know you're frustrated. And we go through these hearings and we analyze in infinite detail all of the problems that we have; ask ourselves profound questions about minutia, and miss the major point. We're not going to solve this problem as we look at it little segment by little segment. And we may not solve any other problem either.

I'm very much concerned, and I hope when we get around to some of the public expressions of why do we need an HTGR, we don't get ourselves bogged down in well, we don't need it as bad as we need——

Senator Domenici. Amtrak.

The Chairman. Amtrak. Well, I was even going to make it narrower than that. We better not put money into an HTGR; we need an advance concept conventional reactor, or we need a liquid metal fast breeder reactor, so let's don't put our money in that.

Those are derivative questions, but they're not fundamental.

Senator Domenici. Frankly, I believe, Senator McClure, that if the utility industry of the country does not start telling the people about these needs that are going to be unmet, I won't be here, because I don't want to be around here that long, but I'll bet that the utility industry will be the one blamed for the shortage, no one else, and it doesn't make any difference what all this business is. If you can't produce it, it's going to be your fault.

On the other hand, if you produce a capacity that's in excess somewhere, there's going to be 5,000 hearings as to who the hell ought to pay for it, since it's more than you needed yesterday.

Those are all kind of part of what he's saying, but we don't want to go on too long. Unless you have something more to say, we're going to go in recess.

The Chairman. Mr. Burstein has something he wanted to say, and I have one followup comment.

Senator DOMENICI. Oh, good.

The CHAIRMAN. Mr. Burstein.

Mr. BURSTEIN. No, no. I defer to you, Senator.

The CHAIRMAN. All I was going to suggest was to some of our friends in the environmental communities who are very much worried about the quality of our life and the impact upon our society of meeting our needs, I would invite them to look at some of the worst conditions that exist on the face of the Earth, when people who do not have enough strip the Earth to the bare soil in order to meet fundamental needs.

We see the destruction of the rain forests, tropical rain forests, at an alarming rate around this world today in order to produce food, while we in this country have surpluses that rack our ingenuity to cope with.

Most of the environmental destruction that is taking place in the world today is the result of somebody's well-intentioned attempt to regulate human activity in a way which has caused worse effects. The cedars of Lebanon went in World War I to fuel the Turkish Railroad to Cairo. Climates have changed because of the total destruction of forests in areas where population pressures outstripped resource bases.

Unless we are well enough equipped to use our technology to meet our needs, we won't just see Mediterranean islands stripped of oak forests, as they were in recorded history; we won't see denuding of an island called England in order to meet an economic base of the British people; we'll see further wholesale destruction of resource values that environmental communities in this world are justly concerned about, but in my judgment moving in the direction of destroying.

Mr. Chairman?

Senator DOMENICI. We stand adjourned.

[Whereupon, at 5:28 p.m., the hearing was recessed, subject to the call of the Chair.]

APPENDIX V

RESPONSES TO ADDITIONAL QUESTIONS

POST-HEARING QUESTIONS AND ANSWERS
FROM SENATORS McCLURE AND DOMENICI
FOR MR. J. VAUGHAN AND MR. B. RUSCHE
RELATING TO THE
FY 1986 AUTHORIZATION HEARING
BEFORE THE
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
SENATE ENERGY AND NATURAL RESOURCES COMMITTEE
MAY 13, 1985

Breeder Reactor R&D

Question 1:	What roles are assigned to the breeder facilities -- namely Argonne-West, FFTF, and ETEC -- that will enable them to make major contributions to technology development and to the ongoing innovative design studies?
Answer:	Under the President's FY 1986 budget request, the roles assigned to the key breeder facilities enabling them to make major contributions to technology development and to the ongoing innovative studies are described below. In addition to providing the capability to carry out the Liquid Metal Reactor (LMR) development, these facilities are used as a resource for other non-breeder programs, including support to space nuclear power and fusion energy projects as well as Electric Power Research Institute and Nuclear Regulatory Commission (NRC) tests.

Argonne National Laboratory (ANL)-West

Major activities will be conducted at ANL-West in the Experimental Breeder Reactor (EBR)-II, the Hot Fuels Examination Facility (HFEF), and the Transient Reactor Test Facility (TREAT). Planned activities to support the innovative designs include: (1) demonstrating the ability to operate with breached fuel; (2) natural-convective decay heat removal experiments for off-normal plant conditions; (3) passive safety feature testing; and (4) component and

Answer 1 (continued): equipment testing leading to more economical plant capital costs and operations.

In addition, the continued operation of EBR-II as a complete powerplant is important in establishing the operability, maintainability, reliability, and plant lifetime characteristics for future LMR plants.

Fast Flux Test Facility (FFTF)

The FFTF complex (which includes the Fuel Storage Facility (FSF), the Maintenance Storage Facility (MASF), and the Fuels and Materials Examination Facility (FMEF) will have a major role in (1) demonstration of improved LMR inherent safety features provided by reactivity feedback effects (the FFTF will be used to measure the effect of reactivity changes due to doppler, sodium density, radial and axial expansion, and bowing under transient conditions); (2) demonstration of a longer-life mixed-oxide LMR fuel as part of the Core Demonstration Experiment that will enable reductions in fuel fabrication, reprocessing and waste disposal requirements; and (3) testing and operation of advanced control concepts that use artificial intelligence in the man-machine interface for both the operations and maintenance functions. This technology has the potential for increasing LMR operations

Answer 1
(continued): and maintenance personnel productivity and at the same time reduce their exposure to irradiated hardware.

Other ongoing activities include efforts to simplify generic features of LMR's such as the core restraint system, refinements to the structural design as it relates to seismic requirements, and surveillance and inspection techniques.

Energy Technology Engineering Center (ETEC)

The major role assigned to the ETEC facility is the operation of the Sodium Components Test Installation (SCTI) for testing and design verification of liquid metal steam generators. Experience has shown that long-lead times are required to identify and resolve steam generator problems that are the major source of nuclear plant unreliability. Therefore, proven steam generator designs are essential for confident utilization in the advanced LMR concepts.

ETEC will also perform: (1) key non-nuclear feature tests involving natural circulation and advanced shutdown heat removal systems for advanced plant concepts; and (2) testing leading to plant simplifications that have the potential for major reductions in plant design, construction, and operating costs.

Answer 1
(continued): Utilization of these key facilities will play a vital role in the development of advanced LMR concepts while continuing to provide testing capability to support other missions for the NRC, DOE's space and defense nuclear energy and fusion energy programs, international exchange agreements, and private sector industrial research and development.

Breeder Reactor R&D

Question 2: Within the 1986 budget constraints, will we be able to preserve the expertise and technology programs that will be attractive to international collaborative efforts? What specific contributions are we making to the international breeder development efforts?

Answer: The FY 1986 budget request for the DOE Civilian Reactor Development Program will allow the United States to retain essential expertise and facilities to continue support for existing international agreements. These agreements have been providing contributions to international breeder development efforts in the areas of breeder reactor fuels, materials, component reliability and design.

Specific agreements to be continued that contribute to international breeder development areas include (1) agreements with Japan on operational reliability testing in the Experimental Breeder Reactor (EBR-II); (2) fuels and materials testing in the Fast Flux Test Facility (FFTF); (3) Clinch River Breeder Reactor/MONJU technology exchange; (4) joint reliability data collection and advanced liquid metal reactor shielding experiments; and (5) continuing agreements with the U.K., Switzerland, France, and Germany for fuels and/or materials irradiation testing in the FFTF in addition to cooperative efforts with the U.K. on transient testing of fuel in the Argonne National Laboratory (ANL) Transient Reactor Test (TREAT) facility.

Answer 2
(continued): Discussions with Japan will continue in order to explore further collaboration utilizing DOE facilities in jointly supported programs thus potentially reducing DOE program costs. Specifically, discussions are being held with Japan on a cooperative critical experiment program using the Zero Power Plutonium Reactor (ZPPR) facility. This program would address core design issues of a large Liquid Metal Fast Breeder Reactor (LMFBR) and would require significant Japanese resources support during the FY 1986-88 time frame.

In the Nuclear Fuel Cycle area, work will continue to provide for an equitable exchange with Japan and France in remote systems technology, the latter under an Agreement with the Commissariat a l'Energie Atomique (CEA) expected to be signed in the fall. In addition, the criticality data development exchange will continue with Japan contributing $6,300,000 to the task. A fuel cycle exchange agreement with the United Kingdom, which has been active since 1978, is continuing with the planned loan of spectrophotometric equipment to the UK for use in the breeder fuel reprocessing facility at Dounreay. An agreement with the Federal Republic of Germany, also in remote system technology, is expected to be signed early next calendar year.

Breeder Reactor R&D

Question 3: What research efforts and funding levels are planned for the Integral Fast Reactor Concept with the FY 86 budget?

Answer: No funds are designated for the Integral Fast Reactor in the Department's FY 1986 budget request, although we will be able to complete ongoing metal fuel irradiation tests in FY 1986 with funds appropriated for EBR-II operations.

Breeder Reactor R&D

Question 4: Argonne East and West represent the only fully comprehensive complex of test facilities and technology development skills that exists in the United States today. Within the constrained FY 1986 budget, will these Argonne capabilities be sufficiently sustained to provide the necessary expertise and test facilities required to support the innovative design work now under way?

Answer: The President's FY 1986 budget request provides for sustaining key facilities and technology development skills considered essential to support the innovative design work at each of the Department's major nuclear facilities and laboratories.

The capability to pursue these activities will be maintained through adequate support of such facilities as the Experimental Breeder Reactor II, the Hot Fuel Examination Facility, and the Transient Reactor Test Facility.

Breeder Reactor R&D

Question 5: Please provide for the record a copy of the Report of the University of Chicago Special Committee for the Integral Fast Reactor.

Answer: (The information follows:)

UNIVERSITY OF WISCONSIN
Nuclear Engineering Department

153 Engineering Research Building
1500 Johnson Drive
Madison, WI 53706
Phone 263-1646 Area Code (608)

October 31, 1984

Dr. Walter E. Massey
Vice President for Research
and for Argonne National Laboratory
The University of Chicago
Argonne National Laboratory
Argonne, Illinois 60439

Dear Dr. Massey:

This letter constitutes the report of The University of Chicago Special Committee for the Integral Fast Reactor. It is submitted in response to your Charge to the Committee on August 28, 1984.

A. Background

This Special Committee was established by your office in July 1984 to conduct an independent technical peer review of the Integral Fast Reactor (IFR) which has been proposed by Argonne National Laboratory (ANL) as a major focus in the national fast breeder program. The essential features of the IFR are pool layout, metal fuel, and pyro- and electro-reprocessing along with injection casting refabrication in a facility integral with the reactor plant. The review had the following primary objectives:

- Review and assess the overall IFR concept.
- Assess the adequacy of the currently planned IFR program, or alternatives, in satisfactorily resolving technical issues to establish concept feasibility.

The effort was expected to be a top-level review of soundness of the overall concept, overall program plan, technical approach for R&D, etc. The Committee met as a Committee-of-the-Whole on August 28, 29, October 16, and 17. Additional review activities including visits to the Idaho site were undertaken on a subcommittee basis.

The report which follows is divided into several sections as follows:

- Principal Points--advantages which the IFR concept has to offer,
- Additional Points--comments of significance for a discussion of this type,

- Work To Be Done--a listing of some of the more important areas in which work will be required,
- Detailed Comments on Fuels, Reprocessing and Waste Management, and Safety (3 separate sections), and
- Conclusions and Recommendations

B. Principal Points

Our review has revealed many significant benefits associated with the IFR concept. Some of these are of a general nature, while others are in comparison to other breeder reactor schemes. Among the more important are the following.

1. We believe there is a national need for a proven breeder reactor since the breeder represents the one single technology in existence today which has been demonstrated to be practical and to have the capability to provide an inexhaustible source of power. The IFR can be designed and operated with a net breeding ratio of 1.0 in the steady state, eliminating the need for continuing further supplies of fissile material. Furthermore, if in the future the need develops for additional fissile material for nuclear power plants in large, industrialized countries, the IFR could be redesigned to provide a breeding ratio well in excess of unity (e.g., 1.4), thereby meeting such a potential future need.

2. Breeder reactors were initially developed in the U. S., and leadership in that area rested here for over a decade; unfortunately, it now resides in France. The IFR appears to offer a new, exciting approach for the U. S. to recapture leadership in breeder development.

3. The capital costs to develop and demonstrate the IFR metal fuel element and the associated fuel cycle appear to be modest. In addition, the development could be accomplished rapidly. These advantages result from the existence of EBR-II and its adjacent fuel cycle building which is suitable for testing of the proposed high temperature reprocessing and fuel refabrication loop.

4. The IFR offers a breeder concept in which the potential for the theft or diversion of fissionable materials is significantly minimized. Plutonium need never be shipped from the site, it will always exist as part of a mixture of highly-radioactive materials, it will essentially always be in remote facilities, and the large majority of it should always be inside the reactor. The IFR fuel cycle appears to offer significant non-proliferation advantages over fuel cycles based on use of the Purex process.

If in the future, it develops that a single, 300 MWe IFR can be made economic, then political steps to discourage the spread of such reactors to many small countries would be appropriate.

5. The scientific evidence in support of the concept is judged to be more than adequate to justify proceeding rapidly with research and development and demonstration of feasibility as presently envisioned for the FY85 and 86 period.

6. The Committee is favorably impressed by the potential of pyrochemical reprocessing. In addition to theft minimization as discussed above, it offers an inexpensive means of reprocessing (e.g., low capital costs and avoidance of transportation costs since reactor and reprocessing facilities are both on the same site) as well as many operational advantages (e.g., the recovery of volatile fission products is much easier than in the Purex process where this is a major problem, the noble gases are released readily, and the transportation of radioactive waste is avoided.)

7. The high thermal conductivity, low fuel operating temperature, and the expected reactivity coefficients tend to give the metal-fueled reactor the ability to tolerate a variety of transients as readily as, and possibly more readily than, an oxide-fueled reactor.

C. Additional Points

Several further points warrant mention in order to give a better understanding of the IFR concept. These include the following:

1. It has been reliably demonstrated that the Uranium-Fissium* (U-Fs) Mark II fuel element can tolerate 10% or higher burnup, and there is the reasonable expectation that U-Pu-Zr fuel will perform as well. The high burnup potential, a necessary attribute of the IFR concept, has resulted from an important discovery made during the late 1960's, namely, that by designing the fuel element to accommodate about 30% swelling of the fuel, most of the large fission gas bubbles in the fuel become interconnected and the bulk of the fission gas is released to the plenum chamber within the fuel element. With such a design, the fuel element can be operated to very high burnups with acceptable stress to the cladding. This phenomenon of interconnected porosity appears to be independent of the precise alloy, and therefore the burnup data on thousands of EBR-II fuel pins appear applicable to the U-Pu-Zr alloys.

2. The Committee feels it essential that the pyrochemical fuel cycle facility at Idaho be rehabilitated at an early date. Otherwise, valuable time will be lost in the effort to demonstrate the IFR concept.

3. The Committee notes that it is important to make a conceptual design of a full-scale plant in order to examine the economics of the IFR.

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* Fissium is an equilibrium concentration of fission-product elements left by the pyrometallurgical reprocessing cycle demonstrated at EBR-II.

D. Work to be Done

A large amount of work, some of a critical nature, must be accomplished before the technical feasibility of the concept can be adequately demonstrated. Particular points worth noting include the following:

1. A crucial need is to establish firmly the performance of the proposed U-Pu-Zr fuel.

2. It must be demonstrated that the proposed fuel can be fabricated with the desired composition and the required uniformity of composition and dimensions.

3. A flowsheet must be established and the details of the pyrochemical process must be demonstrated to ensure that the process can be suitably scaled up.

4. The proposed program to investigate reactor safety, which seems reasonable, must be pursued diligently. It is noted that a complete exploration of the safety question must await the design of an actual, full-scale plant.

5. The program to perform out-of-pile experimental tests and associated physical modeling of the fuel under transient heating conditions should be carried out.

6. The disposal of radioactive wastes (radwastes) from operations in the Integral Fuel Cycle Facility (IFCF) will require a considerable R&D effort since this aspect of the overall process has received little experimental attention in the previous research program either at ANL or elsewhere. Furthermore, every process generates its own peculiar types of radwaste, and procedures applicable to a given process can not be applied without substantial modification to another. Hence, the ANL group will have to start de novo to characterize the radwastes unique to their pyrochemical process and to work out the necessary chemical engineering techniques to safely treat and package the radwastes generated by operation of the IFCF.

E. Detailed Comments on Fuels

1. Optimum Cladding. The available data clearly establish the superiority of 316 SS compared to 304 SS. Presumably, D-9 alloy will behave comparably to, or prove superior to, 316 SS; however, this will require substantially more experimental testing. The superior performance of 316 SS with regard to diametral and axial stability in fast neutron fluences is a definite advantage.

The experimental evidence, although somewhat limited, points to a greater resistance to cladding breach of 316 SS. Failures appear to be related more to the use of dimples to restrain axial movement of fuel. This is a design problem rather than a materials problem and should be resolvable. With regard to cladding strain, 316 SS swelling is about one-half that of 304 SS (~4% vs ~8%) at 10 atom percent burnup (a/o b.u.). This will reduce the element-element and hex-can-element interactions significantly.

The fuel-cladding chemical interaction also markedly favors 316 SS. The interaction zone between the fuel and cladding is reduced a factor of six to ten over that in 304 SS. The impact will be a marked reduction in cladding wastage which should extend the useful life of the fuel elements.

With regard to predicted cladding response for fuel elements of length typical of a fast reactor, 316 SS clearly is superior to 304 SS and one would anticipate limited failures at or about 10 a/o b.u., given the expected operational parameters, including relatively benign transients.

The limited data available are inadequate to permit a prediction of the behavior of D-9 as a cladding material. Based on metallurgical similarities to 316 SS and to irradiations aimed at establishing its stability as duct material, we can infer a limited response to high neutron fluence. One would expect that the fuel-clad chemical interaction would also be comparable to 316 SS. However, this needs to be confirmed experimentally using U-Pu-Zr as fuel.

Fuel-clad mechanical interactions appear to be a second order effect, given the design parameters expected.

2. Existing Fuel (U-Fs Driver Fuel). The existing data base confirms satisfactory fuel performance, primarily under steady-state conditions, to 10 a/o b.u. More limited data lead to the inference that higher burnups are feasible. A critical point appears to occur at about 3.2 a/o b.u. At this point, fuel porosity reaches ~25% and there is a transition to interconnected porosity which permits a release of gaseous fission products to the plenum and the interpenetration of the sodium bond to the voids. The latter increases thermal conductivity, and the combination of gas release and reduced temperature stabilizes growth. An upper bound may be set by the quantity of solid fission products. Further experiments may be necessary to determine this upper bound.

This fuel appears capable of sustaining a range of transients without excessive damage. The critical factor is the behavior of the combination of fuel and cladding in the fuel element. Here the concern is one of operation to burnups in excess of 10 a/o b.u. with a minimum of failures and including a reasonable spectrum of transients. The steady-state irradiations of short and long Mark II elements confirm their viability to 10-12 a/o b.u.

The questions remaining relate to fuel element behavior during transients such as loss-of-flow and power ramps, and behavior of fuel after clad breach. The available data on both low and reasonably high (~4 MWt/sec) transients confirm little or no fuel degradation in the form of fuel breach or increased cladding strain. Several breached elements operated for extended periods, indicating little or no loss of fuel and minimal swelling.

3. U-Pu-Zr Fuel. When plutonium is added to uranium fuel, it is necessary to use a third constituent other than fissium to raise the solidus temperature sufficiently. Scoping experiments indicate that some combination of uranium-plutonium and zirconium has the requisite properties. This range of alloys has higher solidus temperatures and appears more resistant to fuel-clad interpenetration than U-5% Fs. This should be a definite advantage. However, the data base is inadequate to predict fuel behavior to extended burnups with great assurance. The trends, based on very few tests, are favorable but inadequate. The alloy redistribution within the fuel element appears to be understood; however, more information is required.

With regard to swelling and gas release, U-Pu-Zr should be comparable to U-5% Fs. The available data indicate trends only. It is reasonable to expect the U-Pu-Zr alloys to have:

- resistance against fuel-clad interpenetration comparable to or better than U-Fs for 316 SS clad; and
- comparable swelling and gas release values.

The planned EBR-II irradiations should extend the data base appreciably, including behavior of D-9 clad.

The TREAT tests should provide data concerning postulated fuel behavior during transients. The irradiation to 6 a/o b.u. may be inadequate to confirm behavior at burnups above 10 a/o.

It is concluded that the available data on U-Pu-Zr alloys, albeit limited, are promising. Generally, one would predict their use as driver fuels to be comparable to or better than U-5% Fs. The planned irradiations will extend the data base somewhat; however, they will not provide statistically significant results. It should be recognized that several variables are being examined concurrently and synergisms are possible between fuel and cladding that are not predictable on the basis of available data.

4. Fuel Fabrication. The key factor in fuel refabrication after irradiation is that it will be a batch process so that producing more fuel elements represents a very limited extrapolation. The major variable pertains to the new U-Pu-Zr fuel alloy. Injection casting is sensitive to the range of solidus and liquidus temperatures. A higher solidus temperature will have an impact on initial melting and, more importantly, on solidification behavior. Conditions will vary sufficently so that cold shuts and concommitant incomplete filling of molds may be a factor. An increase in temperature of melt, preheating the molds, or both, should resolve such a problem.

The mold problem may become critical, assuming the process remains as is. The Vycor molds are marginal insofar as softening and possible washout are concerned. It appears that other higher temperature mold materials should be investigated.

Generally, this batch process is relatively simple. It is concluded that no major problems are anticipated in optimizing the parameters to achieve high yields.

F. Detailed Comments on Reprocessing and Waste Management

1. Introduction. This section describes briefly the processes under development by ANL for reprocessing fuel from the IFR and dealing with the high-level radioactive wastes resulting from reprocessing. Section 2 describes the halide slagging process proposed for recovering plutonium from irradiated blanket elements and possibly as an alternative process for removing chemically reactive fission products from irradiated core fuel elements. Section 3 describes the electrorefining process proposed for recovering, partially decontaminating, and recycling uranium and plutonium from irradiated core fuel elements. Section 4 discusses processes for dealing with the radioactive wastes from these processes. Section 5 evaluates the advantages and problems of the pyrochemical processes proposed for reprocessing and recycling uranium and plutonium irradiated in the IFR.

2. Halide Slagging. Halide slagging is recommended by ANL for extracting plutonium from the blanket of an IFR and is one alternative being considered for removing chemically reactive fission products, such as cesium, barium, strontium and the rare earths, from the core. In the first application, molten blanket metal in a beryllia crucible is contacted with a molten salt mixture such as 81 weight percent (w/o) $BaCl_2$ and 19 w/o $CaCl_2$ to which enough $MgCl_2$ or natural UCl_3 would be added to convert all bred Pu to $PuCl_3$ and the small amount of reactive fission products to chlorides. Noble metal fission products formed in the blanket, such as ruthenium, technetium, niobium, and zirconium, would remain in the uranium, which would be recycled through the blanket a number of times until its fission product content was so high that the uranium would be discarded.

Other salt fluxes besides 81 w/o $BaCl_2$-19 w/o $CaCl_2$ could be used for halide slagging of blanket metal. Since the LiCl-KCl eutectic is specified for the downstream core electrorefining step, and since Los Alamos has used it for purifying plutonium, this Committee suggests that the LiCl-KCl eutectic be considered for use also in halide slagging of the blanket to avoid having the more complex mixture of four chlorides to be converted to glass.

If halide slagging is used in pyroprocessing of core material, molten core metal in a beryllia crucible would be contacted with 81 w/o $BaCl_2$-19 w/o $CaCl_2$ (or alternatively LiCl-KCl) to which enough $MgCl_2$ would be added to convert reactive fission product metals to chlorides. The magnesium metal byproduct would distill from the reactor, be condensed on a Fiberfrax cover, and permit chlorination of reactive fission products to go to completion. The feasibility of these proposed separations is indicated by the relative standard free energies of formation of chlorides of the metals being separated:

Table I. Standard Free Energies of Formation ΔG_f^o of Chlorides at 1000 K.

Chloride	ΔG_f^o k cal/g-eq.	Chloride	ΔG_f^o k cal/g-eq.
$BaCl_2$ (r,s)	-83.4	$PuCl_3$	-58.9
KCl (s)	-81.4	$MgCl_2$ (o)	-57.7
RbCl (r)	-81.2	UCl_3 (o)	-54.0
$SrCl_2$ (r)	-81.0	$ZrCl_2$ (n)	-49.2
CsCl (r)	-80.0	$ZnCl_2$ (n)	-35.0
$SmCl_2$ (r)	-80.0	$CdCl_2$ (n)	-30.4
LiCl (s)	-78.8	$NbCl_5$ (n)	-24.6
$CaCl_2$ (s)	-77.9	$MoCl_2$ (n)	- 8.0
$LaCl_2$ (r)	-67.0	$TcCl_3$ (n)	- 7.0
$PrCl_3$ (r)	-66.3	$PdCl_2$ (n)	- 3.8
$CeCl_3$ (r)	-66.3	$RuCl_3$ (n)	- 1.4
$NdCl_3$ (r)	-64.2		

r = reactive fission product
n = noble fission product
s = solvent salt
o = oxidant

Loss of plutonium to the salt would be limited by controlling the amount of $MgCl_2$ oxidant added. Uranium, plutonium, and noble metal fission products would remain in the metallic phase which would be separated from the lighter, immiscible salt phase containing reactive fission product chlorides. Noble metal fission products would then be removed from the metallic phase by electrorefining.

3. Electrorefining. Electrorefining is the process recommended by ANL for partially decontaminating uranium and plutonium in irradiated core fuel elements. Noble metal fission products are removed, as are reactive fission products if these are not previously taken out by halide slagging.

The electrorefining cell consists of a steel crucible into which may be lowered a rotating perforated steel anode basket and one or more rotating steel or zirconium cathodes. The crucible holds a lower layer of liquid cadmium in electric contact with the anode and an upper layer of fused LiCl-KCl eutectic electrolyte in which the cathodes are immersed. Spent core fuel, previously vacuum melted to remove volatile fission products and cast into ingots, is charged in the anode basket. Enough $CdCl_2$ is added to the electrolyte to oxidize all the reactive fission products in the fuel charge and also bring the UCl_3 plus $PuCl_3$ content of the LiCl-KCl electrolyte to 2 w/o. The rest of the uranium and plutonium will dissolve in the cadmium. To electrorefine the fuel a voltage is applied, high enough to transport uranium from the liquid cadmium anode to the cathode but not high enough to deposit the more reactive fission products on the cathode. Electrodeposition is continued until substantially all of the uranium and plutonium in the metal charge and cadmium anode have been transferred to the salt and cathode. Noble metal fission products remain either as undissolved solid or in solution in the cadmium.

At the end of electrolysis the salt phase, still containing about 2 w/o UCl_3 + $PuCl_3$ and reactive fission products, is withdrawn from the cell for temporary storage. The anode basket is next removed and discarded as cladding and noble metal waste. An amount of cadmium metal equivalent to the cadmium chloride charged is also withdrawn.

Next, the salt phase which contained 2 w/o UCl_3 + $PuCl_3$ is returned to the electrorefining cell. Enough lithium and potassium are then added to reduce the UCl_3 and $PuCl_3$ to metal, which dissolves in the cadmium.

Finally, enough salt is removed as waste to keep the KCl-LiCl cell inventory constant and remove reactive fission products from the system. The cathode, on which uranium and plutonium have been electrodeposited, is the partially decontaminated product of the electrorefining operation. The cathode deposit is removed and vacuum melted to separate the uranium-plutonium alloy from entrained electrolyte salt, and the alloy is cast into an ingot to be used for fuel fabrication.

4. Radioactive Wastes. The principal highly radioactive wastes from these refining operation are (1) the LiCl-KCl and possibly the $BaCl_2$-$CaCl_2$ salt mixture containing reactive metal fission products, and (2) the steel anode basket containing noble metal fission products, cladding and some cadmium metal. How these high-level wastes are to be prepared for long-term storage hasn't been fully decided, but the following measures are being considered. The chloride salt fractions from halide slagging and from electrolysis are to be combined with glass-forming oxides such as B_2O_3, Al_2O_3 and SiO_2 and hydrolyzed with high-temperature steam in a melting furnace to form HCl vapor and molten glass. The HCl is to be collected and neutralized in sodium carbonate or lime and can probably be treated as low-level waste. The molten glass would be cast into stainless steel or other containers suitable for long-term permanent waste storage in the same manner as high-level wastes from the Purex process. Further research must be undertaken before the final form of the glass will be specified.

Procedures for dealing with the cadmium-bearing noble metal fission products and tramp metal wastes are less well developed. One process being considered is removal and recovery of the cadmium by distillation, followed by packing the solid residue in stainless steel containers into which molten lead is cast. A second alternative is to package the cadmium-bearing solids directly in steel containers.

5. Evaluation of Pyrochemical Processing. The proposed pyrochemical processes have numerous advantages:

- Bred plutonium can be recovered and recycled to the core with much less delay than in the Purex process, for which 200 days or more of spent fuel storage may be required. Hence, plutonium inventory charges will be lower than in the oxide-fueled breeder.

- Pure decontaminated plutonium is never produced, so that the fuel cycle is practically diversion-proof.

- Reprocessing and fabrication may well be economic on a smaller scale than in the oxide-fueled breeder.

- Because fabrication and reprocessing are done at the reactor site, shipment of fresh fuel to the reactor and spent fuel from it are eliminated. Once given a lifetime supply of natural or depleted uranium, the reactor can run as long as the equipment lasts. Diversion of fissile material in transit is no longer a threat.

- Fuel fabrication costs and probably combined fuel cycle costs will be lower than for oxide fuel.

- The total volume of wastes from the pyrochemical process may be smaller than from the Purex process and oxide fuel fabrication.

A novel feature of the pyrochemical process is its use of high-temperature metallurgy and electrochemistry in processing highly radioactive materials. These technologies are unfamiliar to operators of conventional nuclear power plants. The staff and organizations responsible for the pyrochemical processing and fuel fabrication components of the IFR will have to be specially trained and qualified for this type of work.

Technical problems of the proposed processes include the following:

- Ensuring that the chloride content of glass waste is low enough to prevent water solubility.

- Demonstrating that the long-term water solubility of metallic wastes cast in lead or cadmium is sufficiently low.

- Disposing of the iron anode basket.

- Disposing of the cathode mandrel on which uranium and plutonium are deposited. If made of zirconium it could perhaps be melted into the U-15% Pu-10% Zr alloy proposed for core fuel.

- Controlling the composition of the U-Pu-Zr alloy recycled to the core.

- Casting the U-Pu-Zr alloy whose liquidus temperature is close to the temperature at which the Vycor molds in which the alloy is cast melts.

- Preventing accumulation of a critical mass of plutonium in an electrolytic process in which some plutonium segregation may take place.

- Disposing of the beryllia crucible used for halide slagging. If the crucible can be reused enough times, it may be possible to incorporate it in the high-level glass wastes.

- Disposing of the Fiberfrax cover for the halide slagging furnace in which vaporized magnesium has condensed.

- Determining the fate of fission product iodine. Will it accompany the HCl and require that the sodium carbonate-sodium chloride neutralization product be processed for iodine recovery?

- The variety of wastes from the pyrochemical process may be harder to package and store than wastes from the Purex process.

G. Detailed Comments on Safety

Safety is a very broad topic which includes the behavior of the entire plant as well as that of the core by itself. Safety research needs will be related to the regulatory policy of the Nuclear Regulatory Commission. Safety assessment requires the existence of a plant design.

However, the plant design itself will be influenced by general safety principles, and a research program is necessary to determine these general principles. The safety approach being followed by ANL for the IFR includes a search for fundamental safety-design features and consideration of a wide spectrum of safety aspects, such as operational safety, potential core-disruptive initiators, the consequences of core disruption, etc. Studies in progress or to be performed include the following:

- The margin to failure as a result of design basis accidents for both normal and off-normal operation.

- Fuel failure propagation as a result of local faults. There is evidence that this will be of less concern with metal than with oxide fuel.

- The feasibility of avoiding core disruption for both Loss-of-Flow and Transient-Over-Power accidents coupled with failure to scram. There is evidence that metal fuel may offer advantages over oxide fuel here. These arise in part because the average temperature of the metal fuel is smaller than for the oxide fuel.

- The potential for significant energy release if a core disruptive accident were to occur. ANL personnel believe that the argument for low energy release can be made more reliably with metal fuel than oxide fuel.

- The effect of the high heat capacity of a pool-type reactor and innovative designs on reduction of the potential for failure of the decay heat removal systems.
- The role of fission-gas driven, axial fuel expansion in transients and accidents.

ANL expects axial fuel expansion to be a reliable and significant shutdown mechanism during transients and accidents. An in-pile test program in TREAT should provide important integral test information on this effect.

Out-of-pile heating experiments on pre-irradiated fuel, coupled with detailed experimental and theoretical insight into fission gas behavior in metal fuels during transients, will be important to the accomplishment of a more sophisticated model for the fuel expansion effects.

Ultimately, when the necessary plant design information is available, studies on seismic safety, on containment behavior in degraded core melt accidents, on the fission product source term, etc. will be appropriate for the IFR, as for any LMFBR. ANL personnel plan to initiate studies in these areas as part of the IFR and associated studies. However, it is not to be expected that they can be completed within the first two year period of study.

We believe that the Safety R&D program will provide important, confirmatory data during FY85 and 86 time period, but we do not expect the data will be sufficient to resolve all of the issues which will be raised. We also believe the planned schedule appears reasonable for obtaining the data and for performing analyses.

From this initial review, the experimental program, both out-of-pile and in-pile, shows evidence of being well planned and technically sound. We believe that ANL personnel can reasonably proceed with their plans. However, we also believe that a more detailed review of the proposed program should be made and that such reviews should be of a continuing nature.

H. Conclusions and Recommendations

It is the Committee's conclusion that:

- The IFR concept offers many important benefits, and
- The scientific evidence on which the present concept is based, although limited, is sound.

It is strongly recommended that ANL move forward at a rapid pace to explore further the feasibility of the concept.

Sincerely,

Max W Carbon

Max W. Carbon
Chairman

Committee Members:
- Wallace B. Behnke, Jr.
- Manson Benedict
- Hans A. Bethe
- Spencer H. Bush
- Walter J. McCarthy, Jr.
- David Okrent
- Lombard Squires
- Richard Wilson

MWC:cc
cc: Committee Members
Nancy M. O'Fallon
Alan Schriesheim
Charles E. Till

Breeder Reactor R&D

Question 6: In Mr. Vaughan's testimony, he indicated that the University of Chicago review of the IFR (reference previous question) raised a number of questions as to whether the nonproliferation advantages of IFR were as great as touted. I have read this review myself, and nowhere in the review do I find any statements to that effect. To the contrary, the review identifies very positive advantages of IFR over the Purex fuel cycle based on nonproliferation and diversion-proof aspects of the IFR concept. Specifically the review states that "the IFR offers a breeder concept in which the potential for the theft or diversion of fissionable materials is significantly minimized. Plutonium need never be shipped from the site, it will always exist as part of a mixture of highly-radioactive materials, it will essentially always be in remote facilities, and the large majority of it should always be inside the reactor. The IFR fuel cycle appears to offer significant nonproliferation advantages over fuel cycle appears based on use of the Purex process."

Would DOE care to clarify its original comments made during the hearing?

Answer: The University of Chicago's review of the Integral Fast Reactor (IFR) concludes that with the IFR fuel cycle, the potential for theft or diversion of fissionable material from the reactor site is minimized if reprocessing is co-located on the reactor site. However, a Purex process for oxide fuel can also be designed as an integral system with low decontamination factors and without plutonium separation from uranium and, thus, could offer comparable diversion resistance. It was on this basis that Mr. Vaughan's comments were provided.

Breeder Reactor R&D

Question 7: At the hearing, Mr. Vaughan stated that "...in the metal fuels, it's easier to separate and get the plutonium than it is in the oxide form." Considering the high amount of radiation from the fission products that remain in the metal fuels throughout the reprocessing process, and considering that plutonium is never separated from the fission products or from the uranium fuel, as would be in the case in the Purex process for oxide fuels, how can Mr. Vaughan make such a statement? Would he wish to clarify this for the record?

Answer: The context of Mr. Vaughan's statement was in relation to use of the material for unauthorized and illicit purposes. Mixtures of plutonium and uranium are generally considered to be more desirable in the metal form than in the oxide form. This is because more process steps are required to obtain metal plutonium from the oxide form.

However, the relative ease with which "weapons-capable" material, i.e., not necessarily in the pure plutonium metal form, could be obtained from the two fuel forms would depend on many factors. These factors would include specific facility design features, processing parameters, safeguard procedures, and--if separation were done clandestinely--the capabilities of the threat group.

We believe that either a metal or mixed-oxide concept can be adequately protected in the U.S. against any unauthorized acquisition and use of the nuclear material.

Management Structure

Question 8: The nuclear R&D programs have been significantly restructured in the FY 86 budget request. Will there be any parallel management restructuring changes made to reflect these program changes?

Answer: The Office of Nuclear Energy is planning a reorganization to parallel new program priorities that will provide better organizational focus on (1) solutions to near-term revitalization of the nuclear option through advanced LWR research and development; (2) elimination of institutional disincentives; (3) advanced reactors research and development; and (4) a stretched-out schedule for breeder reactor technology development.

Low-Level Waste Program

Question 9: Because of the Department's active involvement with States in the development of low-level waste repositories, I wonder if you could provide either here, or for the record, the following information: (a) the estimated time required for selection, licensing, and development of a low-level waste site; and (b) further details on the types of advanced treatment and disposal technologies available today, and the cost-effectiveness and licensability of each of these technologies.

Answer: The Department has estimated the length of time to complete critical milestones and decision points in a typical facility development process. Though conservative, we consider this schedule achievable and within the requirements of the proposed Amendments to the Low-Level Radioactive Waste Policy Act. Sequentially, development of a management plan and selection of a host State should require approximately 1 year to 18 months. Site selection should require an additional 6 months to 1 year; the disposal technology to be employed at the site should also be decided in this time frame. Site characterization, facility design and the preparation of a license application should require about 2 years. License approval and construction of the facility should also require about 2 years.

Currently, disposal of low-level waste in the near-surface environment by shallow land burial is practiced in the three commercially operated facilities in the U.S. and at DOE low-

Answer 9
(continued): level waste disposal facilities. Alternative technologies to shallow land burial that are felt by many to be acceptable include below ground vaults, earth mound concrete bunkers, augered holes, above ground vaults and mined cavities. Some of these technologies are practiced in other countries; however, little information has been made available that would allow a comprehensive analysis of their performance compared to the performance criteria in 10 CFR Part 61, "The Licensing Requirements for Land Disposal of Radioactive Waste." The Nuclear Regulatory Commission and the Environmental Protection Agency are examining these technologies in terms of licensability and cost effectiveness. The Department is also exploring these alternative technologies as part of its program to assist States and compact regions in determining appropriate technologies and facility designs for low-level waste disposal.

Enclosed is an excerpt from a report prepared for House Interior Committee Chairman Morris K. Udall that describes the achievements and relative cost effectiveness of employing various volume reduction and waste treatment technologies.

Answer 9 (continued):	Also enclosed is a document that describes treatment technologies, "Low-Level Radioactive Waste Management Handbook Series: Low-Level Radioactive Waste Treatment Technology," (DOE/LLW-13Tc).

(The enclosures follow:)

Overview of Achievements in Waste Volume Reduction

Question

"Provide an overview of achievements in waste volume reduction that have been implemented recently, on a national level and by various types of waste generators. What kinds of volume reduction can be achieved in the future, assuming various levels of disposal cost?"

Response

Nationally, the volume of radioactive waste shipped to commercially operated disposal facilities has decreased by 4 percent between January 1979 and December 1983, while the number of operating reactors has increased. The nonreactor sector achieved a 23 percent reduction. Reactor waste shipped for disposal increased overall by 15 percent; this increase was totally attributable to new reactors coming on line. On a per megawatt basis, reactor low-level waste shipped for disposal decreased by 5 percent. Table 4 summarizes these volume reductions.

TABLE 4. LOW-LEVEL WASTE VOLUME DISPOSED 1979—1983 VOLUME (CUBIC FEET)

	1979	1983	%Change
Total Volume	2,822,000	2,709,000	- 4
Volume from Nonreactors	1,418,000	1,095,000	- 23
Volume from Reactors	1,404,000	1,614,000	+ 15
Total Rated Reactor Power, Megawatts	48,168	58,118	+ 21
Reactor Waste Volume/Megawatt	29.15	27.77	- 5

Factors that have influenced this trend reduction are increasing disposal costs and changes in disposal regulations. From 1979 to 1983 net disposal prices have increased by a factor of four-to-five, from approximately $5.00/cubic foot in 1979 to a range of $20.00-to-$25.00 in 1984. Various volume reduction measures have been taken over this 5-year period, by both reactor and nonreactor generators. These improvements have become cost-effective as disposal costs increase. Additionally, regulatory changes for some wastes produced by medical and research institutions have allowed these generators to dispose of some wastes as nonradioactive waste.

Future volume reductions can also be expected to be driven by increasing disposal costs or by new regulatory requirements. As shown in Table 4, some volume reduction has already been achieved. Future increases in disposal cost or changes in regulations may not achieve the same magnitude of volume reduction. For some waste streams, significant investment is required to install new equipment that may result in only a small decrease in waste volume. In such cases, the law of diminishing returns applies. New equipment and procedures can be expected to be utilized when the cost imposed by increasing disposal prices exceeds the cost to build, install, operate, and maintain new volume reduction equipment and procedures. Typically, the low- and moderate-cost improvements which result in volume reduction have already been implemented. The cost to build, install, operate, and maintain new equipment and procedures will vary, depending on the specific equipment, size of equipment, and type and volume of waste being processed. Decisions to institute a volume reduction program will depend on each generator's specific cost basis for evaluating the breakeven point. Therefore, increases in disposal prices will not impact all generators equally, nor could any increase in cost be expected to produce reasonably predictable waste reductions on a per generator basis.

Some analysis of increasing disposal prices on volume reduction options has been conducted for reactor plants by the Electric Power Research Institute (see Figures 1 and 2).

As shown in Figures 1 and 2, the benefit from volume reduction (VR) varies for boiling water and pressurized water reactors. Additionally, the benefits from boiling water reactors will depend upon the type of cleanup system used.

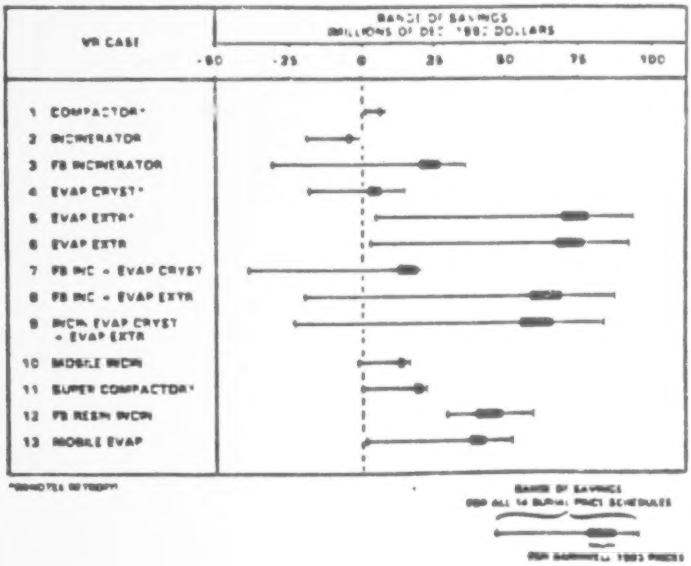

Figure 1. Range of Savings for all Volume Reduction Cases--Twin Boiling Water Reactors with Deep-Bed Condensate Polishing System. Source: Long-Term, Low-Level Radwaste Volume Reduction Strategies, Vol. 2 Economic Analysis, EPRI NP-3763.

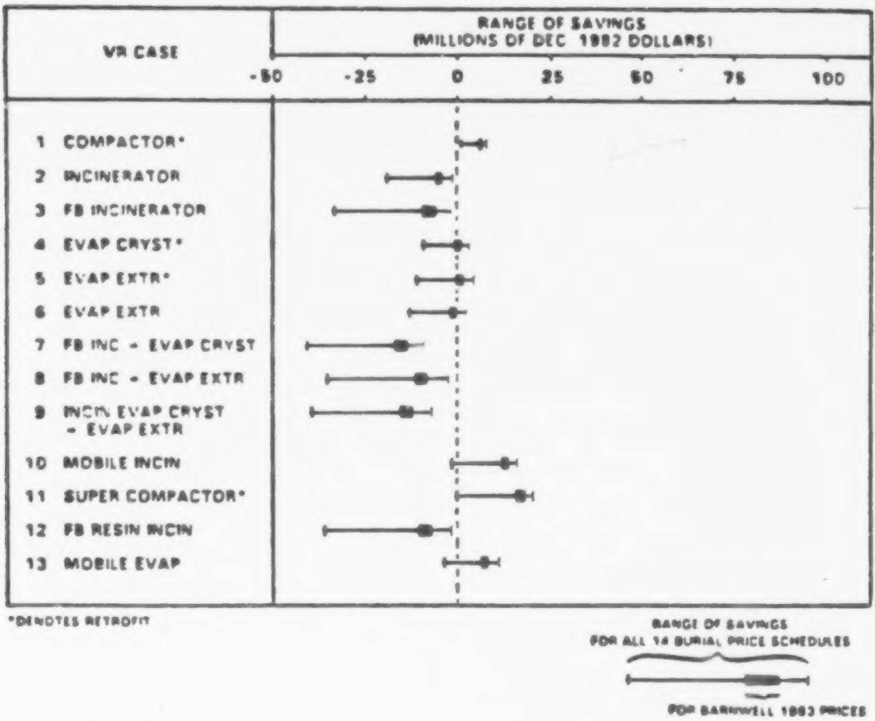

Figure 2. Range of Savings for all Volume Reduction Cases--Twin Pressurized Water Reactors with No Condensate Polishing System. Source: Long-Term, Low-Level Radwaste Volume Reduction Strategies, Vol. 2 Economic Analysis. EPRI NP-3763.

Several viable technologies capable of producing significant reductions in low-level radioactive waste volumes are available in the commercial sector. Several more technologies are also being marketed or developed that treat low-level waste to produce improved waste disposal characteristics with minor decreases in volume; in some cases treatment methods can result in increased waste volume. Many companies are actively positioning themselves in the market to provide a variety of equipment and services to low-level waste generators, primarily the utilities. Table 5 presents a partial listing of several types of volume reduction systems that are available through various venders of volume reduction services or equipment.

TABLE 5. VOLUME REDUCTION SYSTEMS CURRENTLY AVAILABLE

1. High Pressure Compactor
2. Stationary Incinerators
3. Fluid Bed Dryer/Incinerator
4. Evaporator Crystallizer
5. Evaporator Extruder
6. Mobile Incinerator
7. Ultra High Pressure Compactor
8. Mobile Thin-Film Evaporator

Source: Long-Term, Low-Level Radwaste Volume Reduction Strategies, Electric Power Research Institute, EPRI NP-3763, Vol. 1, November 1984.

The emergence of a mobile incinerator for the concentration of dry active waste and a portable, ultra high force super-compactor for the compaction of both combustible and noncombustible dry waste represent two alternatives that require no extensive capital outlay by the generator. Both technologies can provide volume reductions on the scale of 10 to 1, 100 to 1, or greater, depending on the type of waste. These services can be provided to customers at large. Several other service organizations have informally expressed that they intend to provide similar reduction services at existing facilities, through more conventional brokerage arrangements.

DOE/LLW-13Tc
Distribution Category: UC-70B

LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT HANDBOOK SERIES

Low-Level Radioactive Waste Treatment Technology

Published July 1984

National Low-Level Radioactive
Waste Management Program
EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

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for the U.S. Department of Energy
Under DOE-Contract No. DE-AC07-76IDO1570

Remedial Action Programs

Question 10: While I wholeheartedly supported DOE's efforts in the areas of remedial action and fully understand the funding commitments required for such a program, I would hope that the Department, in future years, will maintain a balanced overall program, and that research and development efforts will not suffer or take a back seat priority to the remedial action program elements. Would the Department care of comment on its long-range planning commitments with respect to balancing of R&D versus remedial action programs?

Answer: Both programs produce significant benefits to the Nation and it would be unwise to permit benefits to one at the expense of the other.

The Office of Nuclear Energy is preparing a strategic plan for the DOE civilian reactor research and development program. That plan will be issued that will contain objectives, goals, and strategies to accomplish the Department's nuclear energy research and development mission over the long term. Subsequent budget requests will reflect the results of this planning process.

While the various remedial action programs are largely legislatively driven, the resources required to complete these activities are peaking in FY 1986 and FY 1987 and are expected to slowly decline in the out-years. DOE will continue to seek the most effective use of available resources in executing both the civilian reactor development and remedial action programs.

Uranium Enrichment

Question 11: While I realize it is somewhat premature to pose this question, I am curious as to the projected cost per SWU of operation of the Portsmouth GCEP plant as it now exists. Since I understand that DOE plans to test the operation of the first train of the centrifuges this month, I wonder if DOE could provide me with the cost projections, as soon as sufficient data is available, to provide a rough estimate of cost per SWU. Also, what is the current capacity of the GCEP plant, in terms of percentage of our total U.S. enrichment capacity?

Answer: The GCEP facility could begin operation of the first train (760 centrifuges) in October 1985. These centrifuges are of the Set III type. If AGC is selected, a total of 2,880 Set III machines are planned to be installed before switching to the more advanced Set V technology. The contractor estimate for the steady state operating cost for the initial 2,880 Set III machines is about $40 to $50 per SWU. If the additional capital cost associated with the facility and machines is included, the estimated SWU cost would be higher than gaseous diffusion. It should be noted that the Process Evaluation Board has not completed their evaluation of Set V centrifuge cost and performance.

DOE Fission Programs

Question 15: Even though the International Fuel Cycle Evaluation's (IFCE) study of fuel cycle alternatives showed no significant nonproliferation advantage for spiked vs. more refined reprocessed fuels, I wonder if IFCE commented on the advantages of spiked fuel in terms of diversion resistance? Has DOE itself addressed the diversion-proofness of spiked plutonium fuels? Wouldn't the diversion-proof characteristics of fuel such as that proposed in the Integral Fast Reactor Concept more than offset any imagined concerns over proliferation?

Answer: The International Fuel Cycle Evaluation (IFCE) concluded that technical measures such as spiking could reduce the risk of theft but would have little effectiveness against diversion. It further concluded that such measures were generally less important for adequate safeguards from among the technical, institutional, and political measures potentially available.

For spiked metal or oxide fuel, the requirement for remote operations would reduce direct access to the material and tend to reduce the potential for theft. The fact that the material is highly radioactive, however, would make it more difficult to accurately measure the material transfers and process inventories and, thus, more difficult to detect if a theft or diversion had occurred.

However, overall safeguards effectiveness of spiking can only be determined based on detailed system design evaluations. For either a metal or oxide fuel cycle plant, it is not clear

Answer 15
(continued): that spiked fuel offers significant benefit for protecting against theft or diversion, particularly in the context of an integrated facility safeguard system encompassing both domestic accountability and physical protection requirements and international safeguards considerations.

APPENDIX VI

ADDITIONAL MATERIAL SUBMITTED FOR THE RECORD

STATE OF WYOMING
OFFICE OF THE GOVERNOR
CHEYENNE 82002

ED HERSCHLER
GOVERNOR

May 1, 1985

Honorable Pete V. Domenici
United States Senator
SD-434 Dirksen Senate Office Building
Washington, D.C. 20510

Dear Senator Domenici:

I understand that your subcommittee on Energy Research and Development of the Senate Energy Committee will conduct a hearing on DOE's civilian nuclear program on May 13, 1985. I would ask that this letter be considered as part of the hearing record, inasmuch as I have commitments in Wyoming which preclude my personal attendance at the hearing.

My message to your subcommittee is short, clear and painful--Wyoming's uranium industry is not viable. By 1979, our uranium industry had become a significant factor in Wyoming's economy, with 19 operations employing over 5,400 workers. The Wyoming uranium industry has plummeted from this peak to the 1984 low of only 4 operations employing 1,200 workers. We have had additional layoffs since this figure was calculated, with the latest reduction announced today by Rocky Mountain Energy at its Bear Creek operation in the southern Powder River Basin.

I fail to see how this depressed industry can meet even moderate increases in demand due to supply shortfalls. Furthermore, assuming that our "moth-balled" mines could quickly restore capacity, the impact which would be created due to the increased employment at the mines and in derivative services would be extremely difficult for our communities to handle. Our state permitting process and environmental standards would also come under increased stress, as the nation's demand for uranium would quickly overshadow state regulatory requirements.

Wyoming is prepared to meet its share of the nation's energy needs. However, we shouldn't be expected to meet those needs at a moment's notice, to the detriment of our

Honorable Pete V. Dominici
Page 2
May 1, 1985

communities' infrastructure and services, and our state's environmental standards and requirements.

I would strongly encourage that these considerations be a part of DOE's determination of the capability of the domestic industry to meet hypothetical uranium shortages in future years.

I would also encourage Congress to take swift and appropriate action, before the Department of Energy, by administrative fiat, renders the statutory protections of the viability determination entirely meaningless. I have received a copy of testimony on this issue and on DOE's questionable enrichment program, delivered on behalf of the American Mining Congress, which raises significant issues concerning DOE's decisions, criteria and practices. I am enclosing this testimony for your review and consideration. I would hope that these issues can be addressed and resolved before the last remnant of our domestic uranium industry becomes jeopardized and ceases production.

Thank you for considering my views on this important matter. With best personal regards, I am

Yours sincerely,

EH:nfp

Enclosure

cc: Hon. Morris K. Udall
Hon. Alan K. Simpson
Hon. Malcolm Wallop
Hon. Dick Cheney

Supplemental Written Testimony for the American Mining Congress
Hearing on Uranium Supply
Subcommittee on Energy and the Environment
House Interior Committee
March 21, 1985

This Supplemental Written Testimony, submitted on behalf of the American Mining Congress, is directed at three issues of importance to this hearing which merit somewhat more detailed treatment than can be supplied in oral overview. The three issues are (a) the October 6, 1983 regulations issued by the Department of Energy (DOE) tc employ to assess the viability of the domestic uranium industry, (b) DOE's purported viability determination of December 31, 1984 under those regulations, and (c) the impact of new DOE enrichment policies.

I. DOE's Viability Regulations

A. Development of the Viability Regulations

Section 170B(a) of the Atomic Energy Act, 42 U.S.C. § 2210b(a), requires the Secretary of Energy to "establish by rule . . . specific criteria which shall be assessed in the annual reports on the domestic uranium industry's viability". Section 170B(c) provides that the criteria established under subsection (a) shall . . . include, but not be limited to --

> (1) an assessment of whether executed contracts or options for source material or special nuclear material will result in greater than 37-1/2 percent of actual or

projected domestic uranium being supplied by source material or special nuclear material from foreign sources;

(2) projections or uranium requirements and inventories of domestic utilities for a 10-year period;

(3) present and probable future use of the domestic market by foreign imports;

(4) whether domestic economic resources can supply all future needs for a future 10-year period;

(5) present and projected domestic uranium exploration expenditures and plans;

(6) present and projected employment and capital investment in the uranium industry;

(7) the level of domestic uranium production capacity sufficient to meet projected domestic nuclear power needs for a 10-year period; and

(8) a projection of domestic uranium production and price levels which will be in effect under various assumptions with respect to imports.

DOE published proposed criteria implementing Section 170B at 48 Fed. Reg. 36792 (August 12, 1983). In the preamble to the proposed criteria, DOE forthrightly defined a viable domestic uranium industry as an industry capable of meeting the _total_ needs of the U.S. domestic nuclear power industry. More particularly, DOE explained that it

> proposes to assess the viability of the domestic uranium mining and milling industry by determining whether that industry _will be capable, at any particular time, of supplying the total needs of the domestic nuclear power industry under a variety of contingencies ...._ 48 Fed. Reg. 36792 (emphasis added).

Pursuant to this concept, DOE proposed to assess viability in terms of three attributes; namely, resource, capability, operational capability and financial capability. Resource capability was defined as ability to supply all domestic needs for a future ten-year period; operational capability as having production capacity sufficient to meet all domestic needs for a similar period; and financial capability as having the ability to raise sufficient funds to finance the required production capability. To be deemed viable, the proposed criteria required the domestic industry to meet the definition of resource, operational and financial capability at the time of the assessment or be projected to do so within two years. 48 Fed. Reg. 36792.

The final criteria published at 48 Fed. Reg. 45746 (Oct. 6, 1983), differ dramatically from those originally proposed. Indeed, Secretary Hodel's final criteria are a 180 degree reversal of the concept of viability earlier endorsed by DOE. In contrast to the proposed version which defined a viable domestic uranium industry as one capable of supplying all U.S. requirements, the final version defined a viable domestic uranium industry as one capable of supplying incremental U.S. demand resulting from unspecified import disruption scenarios if such incremental demand could not be met by stockpiles.[1] as the Secretary indicated in his preamble, his criteria are designed to assess "energy supply security," and not the viability of the U.S. uranium industry. See 48 Fed. Reg. 45746.

As necessitated by the radical change in the concept of uranium viability, the Secretary markedly altered the criteria as originally proposed by EIA. The Secretary also added a totally new criteria labelled "Import commitment dependency". The only criterion not significantly altered by the Secretary was the financial criterion, the one component of the proposal criticized by all commenters who spoke to the issue.

B. The Viability Regulations Are Based on a Flawed Concept of Viability

1. DOE's Concept Conflicts with the Statute

DOE's concept of viability is patently flawed. A starting point is Section 170B itself. The statutory criteria specified in Section 170B(c) which must be incorporated in DOE's regulations require the agency to assess viability in terms (1) of availability of "domestic economic reserves" sufficient to "supply all future needs for a future 10 year period" and (2) of the existence of "a level of domestic uranium production capacity sufficient to meet projected domestic nuclear power needs for a 10 year period". These criteria on their face conceive of viability as ability to service all domestic needs, and not some fragment which arises in the event of DOE's hypothetical conjecture of the possible shortfall (if any) resulting from an undefined import disruption which is not covered by inventories and stockpiles. Indeed, in issuing its proposed criteria, DOE acknowledged that the statute conceived of viability as capability of supplying all U.S. requirements; that was the very definition of viability DOE which originally adopted. See 48 Fed. Reg. 36792. DOE confirmed the obviousness of this choice by specifically determining that there was no substantial issue of law or fact associated with the rulemaking. Id. 36794.

---

[1] DOE testimony in Review of the Status of the U.S. Domestic Uranium Mining and Milling Industry, Hearing before the Energy Research Development Subcommittee of the Senate Energy and Natural Resources Comm., 98th Cong., 2d Sess. at 51 (1984).

DOE's concept of viability also abandons the common meaning given the term in the English language. The dictionary defines "viable" to mean

> 1. capable of living.
> 2. a. capable of growing or developing . . . or developing adequately.
>   b. capable of existence or development as an independent unit.[2]

---

[2] Webster's New Collegiate Dictionary 1293 (1983).

As applied to an industry, this suggests a focus on economic well-being and long-term growth and development.3/ DOE's purported focus on the ability to supply hypothetical incremental shortfalls (if any) bears no relation to the common understanding of viability.

2. DOE's Concept Conflicts with the Interpretation of Similar Language in Section 161(v)

Further evidence of the error of DOE's interpretation arises out of the Atomic Energy Act itself. Section 161(v) of the Atomic Energy Act requires the Atomic Energy Commission, now DOE, to "assure the maintenance of a viable domestic uranium industry". Congress' use of the concept of a viable domestic uranium industry in Section 170B bespeaks an obvious intent to import the meaning of the term which had developed under Section 161(v). Moreover, one is generally under a "plain duty" to construe statutes "harmoniously . . . where that can be done". Hyrup v. Kleppe, 406 F.Supp. 214, 217 (D. Colo. 1976). See also Grindstone Butte Project v. Kleppe, 638 F.2d 100, 102-03 (9th Cir. 1981); 2A Singer, Statutes and Statutory

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3/ In confirmation, cases discussing "viability" in the business and bankruptcy context adopt such a view. For example, In re Penn Central Transportation Company, 325 F.Supp 302, 304 (E.D.Pa. 1971) describes "viability" as the ability of a business to "generate some income available for the payment of fixed charges" and to be "self-sustaining". It follows that a viable domestic uranium industry means an industry which is self-sustaining -- i.e., can exist, grow and develop.

Construction (Sands 4th ed. 1984) § 53.01 at 550. It is thus appropriate to examine the meaning of viability under Section 161(v) for purposes of its meaning under Section 170B.

The uranium viability proviso in Section 161(v) had its origin in concerns expressed in 1963 that the domestic uranium industry would not be able to compete against uranium supplied by Canada, South Africa, and other low-cost or subsidized producers.4/ These concerns were reiterated in 1964, the year in which Section 161(v) was enacted.5/ Indeed, the language currently embodied in Section 161(v) was adopted from suggestions made by Kerr-McGee Corporation.6/ The intent of the language as presented by the uranium industry was to assure (1) the existence of a market for U.S. uranium during periods of slack demand and (2) participation by U.S. producers in any growth of demand which was experienced.7/ This intent was reaffirmed in

---

4/ See, e.g., 1963 Hearings at 115 (testimony of Mr. Bokum); 1963 Hearings at 28-30 (Commissioner Wilson and AEC General Counsel: imposition of license and enrichment restrictions to protect against cut-rate foreign competition).

5/ See, e.g., 1964 Hearings at 5 (Commission will voluntarily not enrich foreign-source material for domestic end-use through at least July 1975 in order to assure the maintenance of a viable U.S. producing industry); 1964 Hearings at 312 (statement by Mr. Bokum); id. at 154 (low-priced Canadian and South African supplies).

6/ See 1964 Hearings at 197-98 (suggested language).

7/ See, e.g., 1964 Hearings at 154 (testimony by Mr. McGee concerning questionable survival of domestic uranium industry in the face of low-cost foreign operations and dangers of return to dependency by U.S. on foreign supplies).

explanations offered by the Joint Committee and its members for uranium viability proviso. An exchange in the 1963 hearings before the Joint Committee is particularly telling.

> Senator Anderson: Does this bill allow a foreign raw material producer to bring in his raw material, have it enriched by toll process, and then dumped into the United States, sold in the United States . . . .
>
> Dr. Wilson (AEC): The bill does not now so provide [any prohibitions] . . . .
>
> Senator Anderson: And you would not mind if we amended it to so provide? . . . .
>
> Mr. Hennessey (AEC): . . . . We will be glad to work with the committee staff in drafting that language.[8]

The Joint Committee subsequently reported the Private Ownership legislation, indicating specifically that "viability" for purposes of Section 161(v) hinged on "the condition of the domestic uranium industry".[9] "[I]t would be reasonable," the Joint Committee added, "to place restrictions upon the performance of services by the Commission where the enrichment of foreign material would have an adverse effect on the domestic uranium industry".[10] Congressman Aspinall, a Member of the Joint Committee, explained on the floor of the House that Section 161(v) was intended to "protect our [domestic uranium] industry from possible ruinous competition . . . by providing a flexible restriction on enrichment of foreign uranium".11/ Congressman Morris, another Committee member, likewise observed that subsection (v) would "protect our industry against ruinous competition from cheap foreign uranium".12/

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[8] 1963 Hearings at 28-29.

[9] S. Rep. 1325, 88th Cong., 2d Sess., 1964 USCCAN at 3135.

[10] *Id*. at 3121.

AEC's consistent and contemporaneous construction of Section 161(v) confirms that the language was designed to assure the growth and development of a domestic uranium industry capable of satisfying U.S. demand. Shortly after the statute was enacted the AEC adopted factors to assist it in evaluating domestic uranium industry. These factors focussed on the economic well-being and growth potential of the domestic production industry.13/ The AEC repeatedly testified that Section 161(v) was devoted to assuring the economic viability of the domestic

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11/ 110 Cong. Reg. 20145 (1964).

12/ Id.

13/ The Commission adduced the following factors for consideration for viability purposes:
- -size of market
- -price of uranium when restrictions are removed
- -size of domestic ore reserves
- -rate of development of new reserves
- -probably penetration of the domestic market by foreign imports; and
- -size of export market.

AEC Statement Paragraph 17 (Sept. 3, 1968) in Status of the Domestic Uranium Mining and Milling Industry: The Effects of Imports, Hearing before the Energy Res. & Dev. Subcomm. of the Senate Energy Comm., 97th Cong., 1st Sess. (1981 Hearings) at 415. .

uranium producing industry. For example, in the 1972 AEC Authorization Hearings, Dr. Schlesinger (the Chairman of the Commission) explained that any modification in the then-existing import restriction would remain consistent with a growing domestic industry. In particular, he explained that any revision:

> would be adjusted so as to take an unbearable load off American suppliers, but would still permit the growth of American industry . . . . If there are American reserves to be exploited the intention would be that those reserves would be exploited.14/

The following exchange ensued:

> Rep. Hosmer: In other words, whatever this thing comes up to be, it will be on the basis of maintaining a viable and expanding raw materials industry in the United States?
>
> Dr. Schlesinger: Yes, sir.
>
> Rep. Hosmer: There is no question about that?
>
> Dr. Schlesinger: No, sir.15/

Similarly, Commissioner Anders testified in 1974 that

> Should there be any indication that the proposed Schedule is endangering domestic industry viability, U.S. self-sufficiency, or our national security, the Commission will reimpose restrictions . . .16/

14/ AEC Auth. Hearings, Joint Committee at 2328 (March 1972), reprinted in 1981 Hearings, at 457.

15/ Id.

16/ 1974 Hearings at 6.

This construction was never disputed by the Joint Committee.17/

The Supreme Court has stated that, given the special oversight responsibilities of the Joint Committee on Atomic Energy, special deference is due an AEC construction which "has time and again been brought to the attention of the Joint Committee . . . on Atomic Energy . . . [when] [n]o change . . . has even been suggested by the Committee . . ." Power Reactor Development Co. v. International Union of Elec., Radio and Mach. Workers, 367 U.S. 396, 408-09 (1961). Indeed, "we think it fair to read [such a] history as a de facto acquiescense in and ratification of" the Commission's interpretation. 367 U.S. at 409. See also New Hampshire v. AEC, 406 F.2d 170, 174 (1st Cir.), cert. denied, 395 U.S. 962 (1969). In other words, the AEC's consistent construction of the concept of viability is entitled to virtually binding deference.

When Congress utilizes language in a statute strikingly similar to language in an earlier statute, which language has been consistently interpreted, Congress intends that interpretation to apply to the new statute, absent some strong indication to the contrary. DOE's October 6 viability criteria, based as they are on a patently frivolous notion of viability,

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17/ The Joint Committee in fact encouraged the Commission's construction. See, e.g., 1974 Hearings at 6 (Congressman Hosmer reaffirms intent to maintain a "viable and expanding domestic uranium industry).

are the exact opposite of the concept of viability embodied in Section 161(v).

3. DOE's Concept Leads to Absurd Results

That DOE's reading of the statute in its final criteria is not consistent with the legislative intent is further indicated by the fact that "such interpretation leads to absurd results". 2A C. Sands, Sutherland Statutory Construction § 46.07 at 65 (4th ed. 1973). See also United States v. Bryan, 339 U.S. 323 (1950); Lange v. United States, 443 F.2d 720, 722-73 (D.C. Cir. 1971). DOE's vision of uranium industry viability renders the whole notion meaningless. As the American Mining Congress recently testified,

> "Under [DOE's] concept of viability there . . . could be no . . . domestic uranium industry at all and DOE would nevertheless take the view that it would be viable.[18]

"The absurd implications of such an interpretation are highly probative evidence of a congressional intent contrary to that construction." National Treasury Employees Union v. United States Merit Systems Protection Board, _____ F.2d ____, ____ (D.C. Cir. 1984).

The absurdity of DOE's conception is well-illustrated in the agency's January 4, 1985 "determination" under the regulations that the domestic uranium industry is viable.19/ Although DOE admitted that average domestic costs of production would exceed expected price until at least the 1990's;20/ and that the domestic uranium industry could be expected to shrink further,21/ the agency claimed that the industry was nevertheless "viable". An industry which cannot cover its costs for at least five years is hardly viable and it perverts the English language to contend otherwise.

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[18] See 1984 Hearings, supra, at 105. See also id. at 74.

19/ The "determination," released on January 4, is embodied in three documents: Letter, Secretary Hodel to Mr. Bush, dated Dec. 31, 1984; "Determination of Viability of the Domestic Uranium Mining and Milling Industry"; DOE, Domestic Uranium Mining and Milling Industry; 1983 Viability Assessment (Dec. 1984) ("1983 Viability Assessment").

20/ "In the absence of a supply disruption [i.e., import restraints], average costs of production for U.S. resources are higher than the projected average delivered price between 1984 and 1990". 1983 Viability Assessment xii.

21/ "Nearly all current and expected short-term indicators of the domestic uranium industry's viability are very weak relative to those of recent times:

> Production and capacity utilization are at their lowest levels since 1965 and are expected to decline even further in the short term."

1983 Viability Assessment at xi. DOE's more detailed analysis is somewhat confusing. At page 46 of the 1983 Viability Assessment, DOE projects further decreases in uranium production in 1985 and afterward stagnant, or perhaps a small increase in, production. However, the projections in the body of the "1983 Viability Assessment" are predicated on an excessive demand estimate and, in particular, are supplanted by Appendix F, which takes into account decreased demand due to, inter alia, eight more reactor cancellations. This suggets yet more shrinkage of the industry.

The strained nature of the DOE regulations is also illustrated by their treatment of the industry from the point of view of demand for uranium. When demand for a product is expected to be less than previously projected, the viability of the industry supplying that product cannot be benefitted: simply put, the industry has less of a market for its product and prices and production will be more depressed than otherwise. Yet as DOE makes clear in its January 4 viability "determination", under the agency's strained conception of uranium industry viability, the smaller the demand for uranium, the more viable the domestic uranium industry.[22] A concept of viability which renders an industry more viable as it becomes worse off is patent nonsense.

DOE's October 6 viability regulations and the agency's January 4 viability determination under them amount to an unlawful effort to repeal a statute by administrative fiat. This DOE cannot do: "The power to make regulations . . . is not a delegation of authority to wipe out the statute by imposing an Orwellian definition that adopts no standard at all". Day v. United States, 611 F.2d 1122, 1124 (5th Cir.), cert. denied, 449 U.S. 919 (1980).

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[22] See, e.g., 1983 Viability Assessment xi (if demand is smaller, uranium industry better able to meet supply disruptions and thus more viable). See also id. 68, 77 & Appendix F at p. 180 (with demand cut even more, uranium industry "viable" under DOE criteria).

II. Even Under DOE's Flawed Viability Regulations, the Domestic Uranium Industry is Non-Viable

The viability criteria promulgated by DOE in October of 1983 require the Secretary of Energy to assess the current and projected capability of the U.S. uranium industry to cover a hypothetical disruption in foreign uranium imports. For purposes of the determination, dated December 31, 1984, of viability for calendar year 1983, the Secretary employed a hypothetical disruption of one-third of the Nation's uranium imports (roughly the amount derived from South Africa). Under DOE's viability regulations, if the Secretary finds the domestic uranium industry is incapable of covering the hypothesized one-third supply disruption, then the conclusion is that the industry is not viable. In its determination for calendar year 1983, DOE purported to determine the domestic industry capable of covering a one-third disruption and therefore viable. This determination is erroneous, even under the twisted concept of viability employed by DOE.

At the outset, one should realize that the recent viability assessment actually projects uranium shortages in future years.23/ In some years, the expected shortage would idle roughly 25% of the nation's nuclear generating stations.24/

23/ See, e.g., 1983 Viability Assessment at pp. 78-82 (annual basis.)

24/ 1983 Viability Assessment pp. 78 & 82 (shows as much as 8,000,000 pounds of U_3O_8 demand not covered; this is

(Continued Next Page)

The shortfall would have been far worse if DOE had employed actual cost data which it has in its possession relating to the domestic industsry. More specifically, actual U.S. uranium production cost information collected by DOE demonstrates that the U.S. uranium industry will certainly not be able to cover even a one-third disruption in uranium imports. This cost data,25/ ignored by DOE in its modeling activities, indicates that the industry will continue to shrink under the market conditions projected by DOE. This remnant of production capacity will be insufficient to meet even a modest cut-off of imports. For example, DOE's uranium market model projects market prices of \$30 per pound U_3O_8 in the early 1990's, and erroneously forecasts corresponding U.S. uranium production of over 20 million pounds of U_3O_8. However, when actual cost data is considered, a market price of \$30 per pound U_3O_8 would result in only 7 million pounds of profitable U.S. production -- at a time when DOE estimates U.S. consumption (mid-case) to be 45 million pounds U_3O_8 annually. The balance of U.S. requirements (some 38,000,000

(Continued)

roughly equivalent to the demand of one-fifth to one-fourth of U.S. civilian nuclear power plants).

25/ The cost data, which was not used by DOE for purposes of its assessment, is presented in a graph at page 99 of "Domestic Uranium Milling and Mining Industry: 1983 Viability Assessment."

pounds) must come from foreign sources, leaving the U.S. roughly 80% dependent on foreign uranium imports.

A one-third disruption of an 80% dependency scenario (i.e., the scenario which will apply if DOE would employ actual data as opposed to imagination) would be extremely serious. Under such circumstances, a one-third disruption in uranium imports would immediately require almost a three-fold increase in U.S. production in order to avoid massive fuel shortages. DOE attempts to dismiss this situation by claiming that U.S. uranium production would eventually rise to meet these shortages, resulting in a temporary problem that could be covered by the redistribution of surplus utility uranium inventories. However, DOE is incorrect and unreasonable in assuming that surplus uranium would be sold during a period of supply shortages. The only reasonable conclusion is that, due to the nonviability of U.S. uranium supply capability, this nation is facing potential fuel shortages for its nuclear generating capacity. Moreover, historical experience readily illustrates that U.S. producers cannot bring on new facilities fast enough to cover such a shortfall. Even in the uranium price explosion of the mid-1970's, when uranium market prices increased six-fold, U.S. production rose only 80% over a five-year period. The bottom line is that if DOE employed actual data, the agency would be forced to admit that the U.S. uranium industry will not be able to cover even a modest disruption in import supplies. It follows that the industry is not viable even under DOE's criteria and the agency's narrow concept of viability embodied therein.

III. DOE Enrichment Policies Have Adversely Affected Demand for Uranium

The American Mining Congress and its member companies recognize the need for the Department of Energy (DOE) to develop an efficient, cost-effective uranium enrichment program capable of meeting U.S. enrichment requirements as well as those of the program's foreign customers. AMC believes that a healthy and competitive DOE enrichment program is in the best interests of the domestic uranium industry. However, it is important not to lose sight of the fact that nuclear fuel is comprised of both enrichment services and uranium.

For any given quantity of nuclear fuel, enrichment and uranium can be combined in different amounts. For example, a customer can purchase more uranium and less enrichment, or vice versa. DOE stands in a position of market power in the U.S. nuclear fuel industry and, if not legally or politically constrained, can dictate the combination of uranium and enrichment. If DOE does not interfere, then the economically optimal amount mix depends on the relative prices of uranium and enrichment. If the price of enrichment (usually given in dollars per "separative work unit" or SWU) is relatively high, a customer (if unconstrained by DOE) would prefer to supply more uranium. If the SWU price is low, the customer would prefer to supply less uranium. The combination of uranium and enrichment is ordinarily specified in terms of the "tails assay" of the "depleted" uranium remaining after processing at the DOE enrichment plants. The higher the "tails assay," the more uranium is required to produce a given amount of nuclear fuel; the lower the "tails assay," the more enrichment.

In order to maximize the demand for enrichment services, DOE through its new enrichment contract is restricting the ability of its customer to select the economically optional combination of enrichment services and uranium. This is estimated to reduce demand for uranium by 3,000,000 to 5,000,000 pounds per year.26/

DOE is restricting the selection of an optimal tails assay in three ways. First, the agency is generally barring any selection other than 0.2 for the first two fiscal years. Second, after the initial restriction for the first two fiscal years, DOE is generally restricting the range over which a tails assay may be selected to 0.2 to 0.3. Third, within that range, DOE is placing a surcharge (a kind of penalty) on any selection other than 0.2.

26/ See generally Nuclear Resources International, DOE Enrichment Policies and the U.S. Uraniuim Industry (Sept. 1984) (attached) (discusses impact of numerous DOE policies). The amount of this reduction is equivalent to the capacity output of several medium-sized uranium mills.

It is our understanding that the average tails assay being selected by DOE customers under the agency's arrangement is around 0.23 to 0.24. According to DOE's "Interim Operating Scenarios," the agency intends in the future to operate its plants at a tails assay of 0.35. If DOE is transacting at a tails assay of approximately 0.23, but intending to operate at 0.35, it must be making up the difference in additional uranium requirements from some source. According to reports from the General Accounting Office (GAO), that source is the U.S. uranium stockpile. DOE is pricing the uranium which it intends to distribute from the stockpile pursuant to its planned "split tails operations" at its average acquisition cost in historic dollars ($9.00 per pound, in 1950-70 dollars).27/ This price is about one-half the current depressed market price. It is somewhat unclear how much of the stockpile DOE intends to distribute via its planned split tails program. However, the Interim Operating Scenario document suggests that the amount may be in the range of 100,000,000 pounds over time.

DOE's planned split tails operation merits scrutiny. First, in combination with DOE's restriction on a utility's choice of tails assay, the split tails program amounts to a

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27/ GAO, Information on DOE's Costing and Pricing of Uranium Enrichment Services 16 (April 25, 1984). See also 49 Fed.Reg. 13413 (1984) (price of $26.00 per KgU in form of uranium hexafloride for uranium supplied via "split tails"); id. 13414 (base charge at average historical cost).

transfer of demand for uranium from private suppliers to DOE. In essence, DOE is restricting the ability of its customers to choose an optimal tails assay, but then the agency is selecting its own optimal assay, valuing its uranium at $9.00 per pound, for this purpose. Contrary to what DOE may claim, this amounts to a clear exercise of market power on the part of the agency and is in direct competition with private sector suppliers.

A fundamental question of fairness is posed by the DOE policy in question. As noted, DOE intends to engage in split tails, valuing the federal stockpile at $9.00 per pound (about one-half of spot market prices), and to shift uranium demand from the private sector to the government. We understand that DOE intends these steps to assist it in reducing enrichment costs for bookkeeping purposes by a substantial amount. The domestic uranium industry, however, is currently facing a drastically limited demand for its product. This in part is because DOE's new enrichment contract encourages use of inventories, thus decreasing uranium demand over the near term by tens of millions of pounds. For DOE at the same time to shift demand from private producers to the U.S. government stockpile erases yet more demand from the private sector. DOE is literally destroying the market for U.S. uranium producers. Aside from this fairness question, DOE's policy is also doubtful from a legal perspective. Section 161(v) of the Atomic Energy Act provides that DOE must "assure the maintenance of a viable domestic uranium industry." The split tails program envisioned by DOE appears to conflict with this policy. Moreover, Section 161(m) of the Act requires that DOE obtain "reasonable compensation" for distribution of its property and "not discourage the development of sources of supply independent of the Commission." Distributing stockpile uranium at one-half the spot market price is of questionable reasonableness.[28/] Moreover, under the circumstances, it is hard to see how it can help but discourage the existence of a U.S. domestic uranium industry.

While we believe that DOE should hold down its enrichment costs, it should do so with true efficiencies and not by use of its market power to transfer demand from the private sector to it and not by devaluing government property to below market prices. Moreover, DOE should at all points proceed within the terms of applicable legal requirements.

28/ See GAO Report, supra, at 17.

DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT PROGRAMS—FISCAL YEAR 1986

(Conservation and Renewable Energy Programs)

TUESDAY, MAY 14, 1985

U.S. SENATE,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The subcommittee met, pursuant to notice, at 2:03 p.m., in room SD-366, Dirksen Office Building, Hon. Daniel J. Evans presiding.

Present: Senators Evans, Hecht, Ford, and Bingaman.

Also present: Paul Gilman, professional staff member; Benjamin S. Cooper, professional staff member for the minority; and James T. Bruce, counsel for the minority.

OPENING STATEMENT OF HON. DANIEL J. EVANS, A U.S. SENATOR FROM THE STATE OF WASHINGTON

Senator EVANS. This hearing will come to order.

The fiscal year 1986 oversight hearings on the Department of Energy Research and Development Programs, this one on Conservation and Renewable Energy Programs.

We are pleased to have first the Honorable Donna Fitzpatrick, Acting Assistant Secretary for Conservation and Renewable Energy Programs of the U.S. Department of Energy.

Secretary Fitzpatrick, I will forgo any preliminary statements. In order to get the hearing going and to get to the questions, which I think will be of more interest, I will forgo that just to welcome you here and to say that I continue to have a very strong interest in the opportunities which remain before us in this country for greater efficiency in the use of our energy and gaining greater efficiency, gaining not only greater energy independence but greater economy in the use of our energy.

STATEMENT OF HON. DONNA R. FITZPATRICK, ACTING ASSISTANT SECRETARY, CONSERVATION AND RENEWABLE ENERGY PROGRAMS, DEPARTMENT OF ENERGY, ACCOMPANIED BY AL STREB AND DR. ROBERT SAN MARTIN

Ms. FITZPATRICK. Thank you, Mr. Chairman.

I'd like to introduce my colleagues here today. On my left is Mr. Al Streb the Deputy Assistant Secretary for Conservation, and Dr. Robert San. Martin, the Deputy Assistant Secretary for Renewable Energy.

We appreciate the opportunity to appear today and to provide you with information on our fiscal year 1986 budget request for conservation and renewable energy research and development programs.

The budget for these programs is consistent with and supports the goals and objectives of the fourth national energy policy plan. We have submitted our budget request and detailed testimony for the record, but to put our plans for future activities into better perspective, I'd like to take a few minutes to review briefly some of our research accomplishments to date and the effect that they have had.

Our conservation R&D programs are designed to assist in the development of more efficient technologies and also the availability of alternative fuels rather than fuels based exclusively on fossil sources. For example, in the building sector, due to changes in user behavior application of known technologies and introduction of new technologies, energy use between 1973 and 1983 was reduced by 20 percent per residential unit and by 20 percent per square foot in commercial buildings.

DOE contributed to these improvements, through—to use only two examples: research and development leading to the introduction of new products such as heat pump water heaters, solid state ballasts for fluorescent lamps, and superinsulated residences; and research to provide the basis for industry voluntary standards; for example, ASHRAE standards for infiltration and ventilation, and American Society of Testing materials standard for measuring insulation.

Also in the building sector, the community systems program has accelerated the transfer of modern district heating and cooling technologies to communities throughout the United States.

In industrial energy conservation we have supported research on over 200 technologies in cost shared contracts with the private sector. Of these, 23 are now complete and being commercialized by industry alone. These 23 technologies have saved an estimated 116 trillion Btu's and have penetrated the market sufficiently to push the rate of savings to 40 trillion Btus annually. I might add that this is worth about $400 million a year in energy savings just in the industrial sector.

Typical projects include foam to replace water in textile finishing, high temperature ceramic heat recovery units operating at 2,600 degrees Farenheit, and low-speed diesel co-generation systems.

In the area of transportation, our program accomplishments in electric and hybrid vehicle research include completion of the first generation development of the Ford Motor Co. advanced single shaft alternating current power train for passenger car applications.

In the Automotive Gas Turbine Program ceramic components are being integrated into engine configurations, and rotating ceramic parts will be introduced into the engines at reduced speeds and temperatures. The program has supported a large amount of research on new ceramic materials, processing, and design requirements to allow very high temperature operation. These temperatures are in excess of 2200 degrees Farenheit.

This work has application to a broad spectrum of industrial uses as well as transportation, and technology developed in the program is already being utilized in other commercial markets such as ceramic turbochargers and valve parts.

In our energy conservation and utilization technologies program totally new materials have been developed, such as ductile ordered alloys, which can withstand the severe high temperature operating conditions required for more energy-efficient heat engines and more effective heat exchangers.

As a result of the tribology project, we have discovered a coating that can be used on drill bits that makes them last longer, accommodates increased throughput rates and reduces down time in manufacturing.

Turning now to our renewable energy programs, our 1986 budget request supports the National Energy Policy goal of fostering an adequate supply of energy at reasonable cost by promoting a balanced and mixed energy resource system. Our renewable energy technologies have made remarkable progress during their relatively brief history of intensive research.

Technically, successes have occurred on many fronts. Costs have been reduced by as much as a factor of 10. Efficiencies have doubled, and system life has increased to 20 or more years. We estimate that from 1975 to 1984 the incremental addition of renewables to new energy capacity was 1.2 billion barrels of oil equivalent valued at $39 billion based on world oil prices.

This addition of new energy capacity is the result of Federal research and also extensive private sector research and investment. Working together with the private sector substantial progress has been made in all the facets involved in developing a national renewable energy capability. For example, there are multi-megawatt projects financed by private capital in operation or under development using technologies such as wind, photovoltaics, solar thermal, geothermal, and biofuels. There are countless smaller projects for community energy needs coming on line almost daily.

Internationally, numerous markets are developing for U.S. renewable energy technology. Colleges and universities are training renewable energy researchers and engineers, and the financial community is supporting development projects, as well as providing investment capital to manufacturers for expansion.

Nearly 6,000 companies in the United States are engaged in the manufacture, installation, operation, sales or servicing of renewable energy systems. Ninety percent of these are small- to medium-sized firms. Most are less than 13 years old and are characterized by low profitability but high growth potential.

Sales by the U.S. photovoltaic industry approached $150 million in 1984, representing almost 12 megawatts of shipments. During 1984, 4,500 wind turbines having a capacity of 374 megawatts were installed in the United States, and the wind turbine industry achieved sales of nearly $500 million, an increase of tenfold in the last 4 years.

By the end of 1984, California's major utility companies had signed on operating renewable energy projects totalling almost 900 megawatts. Domestic hot water has emerged as the dominant application in active solar collectors with annual sales currently accounting for more than $500 million. Passive solar heating has become an accepted feature of modern homebuilding. An estimated 100,000 buildings now have passive systems.

In order to conduct the activities which are necessary to sustain this technical momentum, which has been established by the Federal research community and industry, we are requesting a total of $174 million for fiscal year 1986.

Turning now to the Electric Energy Systems and Electric Storage and Electric Energy Systems, program supports mid- and long-term research in support of our national security interests and the reliability and safety of future electric networks. The program's three areas are biological health effects associated with exposure to high voltage electric fields, electric network reliability, and electric system efficiency.

Recent advances in understanding the biological implications of exposure to high voltages, near completion of the world's longest superconducting transmission cable, use of the hybrid computer simulator by industry to analyze electric system problems, testing of advanced load leveling battery systems, and the transfer of more mature systems research to the private sector for further development will have a continued impact on the future electric network.

The energy storage program is the nucleus of all DOE research activities related to advanced energy storage and conversion systems. Important elements of government-sponsored battery research and development are the education of new scientists and engineers, and the transfer of technology to the commercial sector, as well as spinoff applications in areas where performance, durability, and/or cost requirements are less stringent.

I will mention just two examples of the program's success in this area. Under Department of Energy sponsorship, Gould, Inc. has developed a novel, maintenance-free sealed lead-acid battery, which has now been commercialized, and a lithium iron disulfide technology which we developed is now employed in thermal batteries fabricated for the Department of Defense.

In our fiscal year 1986 budget request, the largest investment is in the battery area, because success in developing a battery for either load leveling or electric vehicles could result in a significant reduction in U.S. petroleum consumption.

Let me conclude by emphasizing that the budget submitted for fiscal year 1986 represents a balanced and objective approach to sustaining the momentum achieved in the fields of conservation and renewable energy, and will substantially contribute to the base of technical information required for informed decisionmaking.

This approach, which is consistent with the goals and objectives of the Fourth National Energy Policy Plan, includes public and private cooperation in effective technology transfer efforts to enhance the Nation's ability to use the results of our R&D efforts.

Mr. Chairman, we are pleased to have the advice that we have received from the Congress and in particular this subcommittee, and we thank you for the opportunity to appear here today.

[The prepared statement of Ms. Fitzpatrick follows:]

STATEMENT OF

DONNA R. FITZPATRICK

ACTING ASSISTANT SECRETARY

CONSERVATION AND RENEWABLE ENERGY

U. S. DEPARTMENT OF ENERGY

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES

ENERGY RESEARCH AND DEVELOPMENT SUBCOMMITTEE

UNITED STATES SENATE

MAY 14, 1985

Mr. Chairman and Members of the Subcommittee:

I appreciate this opportunity to appear before you today and provide information on the FY 1986 budget request concerning the Department's energy conservation and renewable energy research and development programs. The budget for these programs is consistent with and supports the goals and objectives of the Fourth National Energy Policy Plan (NEPP-IV). I will summarize those parts of the Plan which are relevant to the subject of today's hearing and discuss related highlights of the FY 1986 budget request.

NATIONAL ENERGY POLICIES AND STRATEGIES

The overall goal of our national energy policy is to foster an adequate supply of energy at reasonable costs. This policy recognizes that "adequate supply" requires flexibility in the energy system, with no undue reliance on any single source of supply. The goal of "reasonable costs" suggests economic efficiency within the energy system, so that energy consumers, individual, commercial, and industrial users alike, are not penalized by economic rigidities introduced into the system by ill-advised governmental regulation. The strategies for achieving this energy policy goal are:

- to minimize Federal control and involvement in energy markets while maintaining public health and safety and environmental quality; and o to promote a balanced and mixed energy resource system.

The FY 1986 budget request for energy conservation and renewable energy research and development programs implements these strategies by supporting development of a mix of technologies that can contribute to both energy supply and improved end-use efficiency. In allocating our resources, we are concentrating on applying Federal funds only where they are most effective; in sponsoring research and development (R&D) where the potential payoff is high, but which private industry cannot be expected to pursue because the results are difficult to predict or a return on investment would require an exceptionally long time to be realized.

In order to carry out this strategy we have proposed a budget for all Conservation and Renewable R&D programs under this subcommittee's jurisdiction which totals $342.9 million. The proposed budget reflects the commitment to support a mix of technologies, which is one of the strategies to achieve our energy policy goal.

I would like now to discuss each of our major program areas under the Office of Conservation and Renewable Energy and its related FY 1986 funding request.

FY 1986 BUDGET REQUEST FOR ENERGY CONSERVATION

Energy conservation, which we define as the elimination of waste and the careful and efficient use of resources, is a basic component of these strategies. We view it as an important energy resource. Indeed, the experience of the last 10 years has proven this to be the case. Despite strong economic growth in 1984, it is estimated that total energy consumption in that year did not exceed that of 1973, and was far below what pre-1973 trends would have produced had those trends continued. Yet economic output over the same period of time continued to expand and energy prices have moderated somewhat. To illustrate the gains in economic and energy efficiency we achieved over that period, the amount of energy required to produce a constant dollar of gross national product has declined by 24 percent since 1973, a 5 percent improvement from just two years ago.

The FY 1986 budget request for energy conservation research and development programs under consideration at this hearing totals $138.6 million. It includes $33.4 million for Buildings and Community Systems, $43.0 million for Transportation Programs, $35.5 million for Industrial Programs, and $26.7 million for Multi-Sector programs.

Buildings and Community Systems

The buildings sector accounts for approximately 36 percent of our total national energy consumption. In residential buildings, space heating, water heating, and refrigeration use the largest amounts of energy; in commercial buildings space heating, lighting, and air conditioning use the largest amounts. Significant energy savings can be achieved by improving the efficiency of these and related building functions. The goal of our Buildings and Community Systems research is to advance the technologies that will make these savings possible.

The FY 1986 budget for the Buildings and Community Systems R&D programs is $33.4 million. These funds will be used to conduct two major efforts: (a) research and development to increase the energy efficiency of buildings; and (b) information and technology transfer activities to make our research results available to potential users.

Research and development activities consist of four subprograms: Building Systems, Technology and Consumer Products, and Community Systems, and Analysis and Technology Transfer.

We are requesting $12.9 million for the Building Systems subprogram in FY 1986 to continue support for a variety of research, including: methods of making building shells more energy efficient; ways to maintain acceptable air quality in energy efficient buildings; and methods to predict and measure the energy performance of buildings to make them more energy efficient. We are also proposing new initiatives in design techniques, construction quality, and lighting quality.

The Technology and Consumer Products subprogram conducts research that will increase the efficiency of energy-related equipment used in buildings. We are requesting $9.4 million for this subprogram. These funds will be used for research into advanced technologies which support development of thermally activated heat pumps, advanced lighting concepts, combustion heating systems, and refrigeration equipment and appliances.

The Community Systems subprogram supports research leading to the development of community-wide energy delivery and energy management systems. We are requesting $2.0 million for this subprogram.

Recognizing the importance of making the results of our research available to the private sector, I want to emphasize the importance we attach to Analysis and Technology Transfer in FY 1986. We are requesting $3.4 million for it, which will include new initiatives to facilitate voluntary energy conservation programs by the utilities, research on consumer responses, and a fellowship program to help support buildings energy studies by university and industry researchers at the national laboratories. We also propose to continue our cooperative efforts with the International Energy Agency and our program assessment and research utilization activities. These funds will also enable us to carry out a study that the Rural Housing Amendments Act of 1983 requires us to conduct to compare the energy impact of national manufactured housing safety standards with HUD and Farmers Home Administration standards.

We are requesting $2.2 million for capital equipment in support of the Buildings and Community Systems program in FY 1986. These funds will be used to continue to equip the Roof Test Center at the Oak Ridge National Laboratory, and for diagnostic, computer data logging, and laboratory test equipment to support indoor air quality, building equipment, district heating and cooling and Federal Energy Management Program activities at DOE national laboratories and universities.

Transportation

The FY 1986 budget request for the Transportation program is $43.0 million to continue R&D in five subprograms: Vehicle Propulsion R&D; Electric and Hybrid Vehicle R&D; Transportation Systems Utilization; Alternative Fuels Utilization; and Advanced Materials Development. The transportation sector consumes 9 million barrels of oil per day, accounting for approximately 27 percent of total national energy consumption and about 61 percent of total use of petroleum. The goal of the Transportation program is to provide the technology base necessary to support private sector efforts to improve energy efficiency in transportation and to develop new technologies which can serve as alternatives to those based exclusively on petroleum.

In FY 1986, $20.1 million is requested for the Vehicle Propulsion subprogram which supports research and development of high efficiency and advanced heat engine technologies. This area includes R&D on the automotive gas turbine and the adiabatic diesel engines and carries out a number of related technology transfer and technology assessment activities. The goals for both the gas turbine and the adiabatic diesel projects are to develop proof-of-concept engine designs which result in at least a 30 percent improvement in energy efficiency over existing technologies, meet current standards for emissions, safety, and noise, and can use several different alternative fuels.

In FY 1986, $6.1 million is requested for the Electric and Hybrid Vehicle subprogram which supports R&D activities necessary to advance the technologies of batteries and propulsion systems for passenger car and commercial van or light truck applications. These funds will be used to continue the development, test, and evaluation of experimental lead-acid, nickel-iron, and sodium-sulfur battery systems and a number of integrated propulsion systems, including advanced powertrains.

The Transportation Systems Utilization subprogram is designed to encourage improved energy efficiency in transportation systems use. The FY 1986 budget requests $1.2 million to support the publication of the Gas Mileage Guide, collection, analysis, and distribution of transportation energy utilization data, and development of technology transfer plans.

In FY 1986, $1.6 million is requested for the Alternative Fuels Utilization subprogram, which is designed to encourage the use of non-petroleum based fuels in transportation. These funds will be used to conduct systematic investigations into the fundamental behavior of alternative fuels in current and advanced engines; to develop and maintain data bases on the properties of fuels derived from oil shale, coal, and biomass; and to continue with Phase I of the Methanol-Fueled Federal Fleet Implementation project.

In FY 1986, $9.3 million is requested for the Advanced Materials Development subprogram. This area addresses the need to develop new materials and engine components that can withstand the high temperatures and corrosive environments of advanced improved-efficiency propulsion systems for transportation applications. To support advanced materials research in both industry and Government, $3.0 million is also requested to complete construction of the user-oriented High Temperature Materials Laboratory at Oak Ridge, Tennessee.

Industry

The FY 1986 budget request for the Industrial Programs is $35.5 million. These funds will be used to carry out work in four subprograms: Waste Energy Reduction, Industrial Process Efficiency, Industrial Cogeneration, and Implementation and Deployment. The goal of these activities is to encourage improved energy efficiency in industry, which accounts for approximately 37 percent of total U.S. energy consumption. The Department's activities in the industrial area consist of a comprehensive program of carefully targeted technological research and development, combined with technology transfer and other implementation efforts.

The Waste Energy Reduction subprogram supports research and development on improved combustion efficiency through oxygen enrichment, improved burner designs, and sophisticated combustion controls; waste heat recovery by development of industrial heat pumps, high temperature recuperators, and ceramic materials for heat exchangers; and research into waste materials utilization and CO_2 generation and recovery. In FY 1986, $12.3 million is requested for this subprogram.

The Industrial Process Efficiency subprogram includes R&D for a major effort in thin strip casting of steel, inert anode materials, advanced sensors and control systems, advanced separation systems, and gasification of wood-derived process liquids for use as fuel. In FY 1986 $13.5 million is requested for this subprogram. This ongoing R&D effort could ultimately achieve as much as 1.0 quadrillion BTU, worth $5 billion, of potential energy savings per year.

The Industrial Cogeneration subprogram focuses on research for externally-fired Brayton cogeneration systems, cogeneration systems powered by diesel engines fired by water slurries, and thermionic burner systems. In FY 1986, $4.7 million is requested in this area.

In addition to the R&D projects which will be funded by the FY 1986 request, there are a number of other R&D projects which are ongoing and supported by prior year funding. These projects include fluidized-bed waste heat recovery systems, conversion of waste materials, laser based sensors, sensors for papermaking processes, separation systems, and cogeneration component research, all of which have significant energy conservation potential.

The Implementation and Development subprogram continues support for the Energy Analysis and Diagnostic Centers at 12 universities, carries out the Congressionally mandated Industrial Energy Efficiency Reporting program, and supports a number of activities for technology transfer. These include targeted workshops, support to selected energy conferences, and the development of written materials describing the industrial energy conservation technology and R&D results. Altogether, $3.2 million is requested for this subprogram.

Multi-Sector

The Multi-Sector Program includes the Energy Conversion and Utilization Technologies (ECUT) program, the Energy Related Inventions program, and the National Appropriate Technology Assistance Service (NATAS). The FY 1986 budget request for Multi-Sector includes $20.7 million for ECUT, $5.0 million for the Energy Related Inventions program, and $1.0 million for NATAS.

The Energy Conversion and Utilization Technologies research programs are oriented toward basic research and crosscutting R&D problems common to more than one energy consuming sector. They also provide predictive models and design tools useful to the private sector in achieving greater energy productivity. The requested funding will be used to conduct research in four subprogram areas: Combustion and Thermal Sciences, Materials Sciences, Biocatalysis, Tribology, and International Research Monitoring.

In FY 1986 $6.5 million is requested for Combustion and Thermal Sciences subprogram. Combustion research is directed toward developing efficient, clean, and reliable combustion systems and devices. Thermal Sciences research is needed to provide the technological base used to improve heat transfer processes, reduce heat transfer surface area requirements, and minimize vibration induced by fluid flow through heat exchangers. In FY 1986 research will continue to develop advanced analysis techniques and to generate a technological data base for the physical sciences of thermodynamics and heat and mass transfer.

The $6.0 million requested for Materials Research will be used to investigate and modify the characteristics of high-temperature materials, lightweight materials, and corrosion resistent materials. Certain materials, such as long-range ordered (LRO) alloys and intermetallic compounds, have great potential for improving the efficiency and performance of high temperature processes, but have not yet been utilized because of their characteristic brittleness. The $3.3 million requested for Biocatalysis research will be used to establish a technological data base for the development of new techniques to manufacture industrial and commercial chemicals using biological systems analogous to conventional processes in chemical engineering. The $3.3 million requested for the Tribology subprogram will be used for research on lubricants, friction and wear to ceramics, and coatings on machine tools that reduce heat and last longer.

Other ECUT funding requested in the proposed FY 1986 budget will be used to assess the status of foreign technologies related to energy conservation and compare with U.S. technologies.

The FY 1986 budget requests $5.0 million for the Energy Related Inventions program. This program was established to evaluate the technical merits of energy related inventions submitted to DOE and to provide technical assistance and grants to further develop promising inventions. The National Bureau of Standards (NBS) conducts evaluations through its Office of Energy Related Inventions. Promising inventions identified by NBS are directed to DOE for further assistance to investigate sources of private sector funding or for direct support where private sector support is not available. From program inception in 1974 through 1984 approximately 20,600 energy saving inventions had been evaluated by NBS. Based on NBS recommendations, 192 inventions were awarded grants totaling $14 million. Of these, 36 have entered the marketplace generating sales of $110 million and creating more than 900 direct jobs.

In FY 1986, the $5 million requested will support the analysis of approximately 2000 proposed inventions and provide financial support for approximately 40 of the most promising inventions. During FY 1986, DOE will continue to work one-on-one with inventors to provide business planning assistance and will conduct workshops which we have tested and found to be very helpful to inventors in dealing with the various and complicated aspects of commercialization.

Appropriate Technology

The Appropriate Technology program was established to support the development and demonstration of small-scale energy technologies that were matched in scale and nature to local needs. Over 2,000 projects were supported, and almost 900 development projects were completed, to advance the state-of-the-art in appropriate technology. In FY 1983, Congress appropriated funds to establish the National Appropriate Technology Assistance Service (NATAS), to disseminate information on the energy conservation and supply technologies developed through this program and to give expert advice and guidance in using them effectively. NATAS was established in FY 1984 and to date has received over 4,000 requests for information and assistance.

The FY 1986 Budget Request contains $1 million for NATAS, for the continuation of information and technical assistance to individuals and small businesses.

FY 1986 BUDGET REQUEST FOR RENEWABLE ENERGY

Renewable energy technologies are playing an important role in achieving the national objective of a mixed and balanced energy resource base at a reasonable cost. This objective of our energy policy is not targeted to specific numbers. The Department's R&D proposals are geared to assist the private sector in developing technologies capable of providing efficient, flexible energy supply systems supporting economic growth and permitting free choice in the marketplace among a wide range of energy options. A private sector infrastructure has emerged and is accepting the challenges associated with incorporating renewables into the energy supply network. These new industries include more than 6,000 companies, which are now engaged in research, development, manufacture, installation, operation, sales, financing, or servicing of renewable energy systems.

This range of involvement includes universities, utility companies, Fortune 500 companies, services firms, small-business entrepreneurs, major financial institutions, professional associations, state and local governments, and private citizens.

Within this spectrum of technology research and development, renewable energy options can be viewed covering the range from immature to maturing and mature. A mature option is one where the technology is relatively developed and close to competitive market levels. Industry involvement is significant and Federal requirements are minimal. A maturing technology is one whose basic concepts are proven and which is beginning to find application in market niches, although applied research or product development is necessary to bring it to broad competitive status. Immature technologies are those for which the central concept has been nearly or completely proven, but for which both basic and applied R&D remain.

The request for FY 1986 of $173.8 million includes activities that span the development continuum of renewable energy. The request will expand the technological and scientific boundaries leading to improved opportunities and innovative ideas to accelerate the harnessing of the renewable energy resources.

I would now like to address the funding requests for selected major programs.

SOLAR BUILDINGS

Solar Buildings Technology addresses the R&D issues associated with both active and passive solar heating, cooling, lighting, and domestic hot water. The FY 1986 budget request for Solar Buildings is $9 million for operating expenses and $.5 million for capital equipment.

Evacuated collector research will involve investigations of alternate materials and design strategies to improve a design that has already experimentally shown the highest efficiency ever achieved by a non-tracking collector. These efforts are aimed at extending both the projected life and operating temperature range of such designs and achieving much lower component and system costs. Thermal storage research focuses upon new materials and component design which may realize the potential flexibility and efficiency of phase change storage for passive solar heating and cooling. Activities in thermal transport will include testing fluidized bed concepts, which concentrate thermal energy from collection surfaces, and thermal diode control mechanisms to transport heat efficiently within buildings.

Systems research efforts concentrate on a number of model validation and experimental test activities. State-of-the-art technology will be tested and evaluated to obtain reliability and durability information. Research on deep penetration core daylighting will proceed using analytical simulations, scale models, and test cells. Additionally, research will be performed to determine optimal combinations of emerging solar materials, components, and systems in different building types within several geographic regions.

PHOTOVOLTAICS

The progress made in the development of PV technology is the result of successful Federal/industrial cooperation. The goal of this partnership is to develop PV technology to the point that it is cost-competitive in the U.S. grid-connected power market. This requires a combination of module and system capital cost reductions and efficiency improvements that will result in an eightfold reduction in the price of photovoltaic-generated power from that seen today.

Incorporating technical advances achieved by the Federal program, industry is ambitiously working to maintain its world leadership. From 1974 to 1984, U.S. module sales have soared from 15 kilowatts annually to 12,000 kilowatts. U.S. industry can now build megawatt size central power stations. Four experimental facilities are now in progress in California. Another market actively pursued by the industry is remote stand-alone applications. U.S. exports, almost exclusively for this market segment, rose 45 percent from 1983 to 1984.

The FY 1986 budget request for Photovoltaics is $43.6 million for operating expenses and $1.2 million for capital equipment. This FY 1986 program proposes to aggressively undertake critical research efforts toward developing advanced technologies that show great promise. The strategy is to continue working with industry to improve the conversion efficiency, life-expectancy, and reliability and reduce the cost of photovoltaic cells and modules. In particular, there is a strong emphasis on thin-film concepts because they require less basic materials and are more amenable to automated production.

Activities in materials research are being directed toward resolving efficiency-limiting characteristics, materials instabilities, and deposition impediments related to thin-film materials. The transfer of silicon ribbon production technology to industry will be completed.

Collector research will focus on problems related to thin-film modules and concentrator collectors based on thin-film, multiple-junction cells. In particular, the development of module fabrication technologies, structures, and less costly contacts and interconnections would be pursued. Efforts to reduce the complexity of flat-plate and concentrator module design will also continue.

Systems research will be completed on crystalline silicon module reliability characterization and will begin characterization of thin-film module reliability. Results of life-limiting failure mechanism experiments will be transferred to industry to assist industry in extending photovoltaic system life from approximately 10 years to about 30. The DOE Program will also assist industry in establishing standard device measurement procedures and performance specifications.

SOLAR THERMAL TECHNOLOGY

The Federal Solar Thermal Technology Program was established to advance the engineering and scientific understanding of this renewable energy option and to establish the technology base for further development by private industry in the competitive energy market.

In addition to the high costs associated with capital expenditures, there are other factors presently inhibiting use of solar thermal technologies. These include efficiency uncertainty, unsubstantiated operations and maintenance costs, perceived technical and financial risk due to lack of operational experience, and unproven system service life.

The FY 1986 budget request for Solar Thermal Energy Systems is $28.1 million for operating expenses and $.3 million for capital equipment. For FY 1986, the primary emphasis of research and development is on developing cost effective solar energy collection technologies. This encompasses concentrators, optical materials, and receivers. Concentrator performance has a strong effect on overall system efficiency. Optical materials, mirrors and lenses, are an integral part of any concentrator. Research is being supported to identify low-cost, lightweight, durable optical materials. Receivers components likewise play a critical role in total system efficiency and research will be pursued to enable the operation of advanced central receivers at higher temperatures.

Research emphasis on energy conversion technology includes processes and components to convert the thermal energy provided by the receiver into electrical, mechanical, or other usable energy forms. The adaptation of heat engines for the parabolic dish electric generation application and the development of lower-cost, high-efficiency energy transport and storage mechanisms will be stressed.

System level research provides real-time data related to operation and maintenance issues. Research will include component integration, system optimization, and the automation of system control. Molten nitrate salts, which represent the next generation of central receiver heat transfer technology, will be tested; and a solar-fossil hybrid power facility will be conceptually designed.

BIOFUELS

Biofuels energy systems utilize a variety of organic materials which are converted by thermochemical and biochemical means into gaseous, liquid, and solid fuels. Biofuels technologies are currently playing a significant role in U.S. energy production by supplying approximately 2.5 quads (3.3 percent) to the U.S. energy supply network.

The FY 1986 budget request for Biofuels is $27.8 million for operating expenses and $.6 million for capital equipment. During FY 1986, the Biofuels Program will focus on key research issues to provide a technology base for private sector development of production and conversion technologies.

In the area of feedstock production, research will focus on genetic hybridization to improve biomass yields and site adaptability, along with tissue culture techniques for breeding and physiological studies. The long-term viability of monoculture plantings, their susceptibility to pests and diseases, and potential yields over successive cycles of harvesting and resprouting from the residual stumps (coppicing cycles) will be examined. Microalgal species will be screened for high algal oil production and experimental-design algal growth units are to be tested for crop management approaches and design adaptations.

A central activity in thermochemical conversion research will be continuation of the scale-up medium-Btu gasification process. This effort, cost-shared with private industry, will define technical and operational boundaries. In the area of municipal solid waste (MSW), research will include: combustion investigations to improve efficiency and steam quality; identification of reactor designs for proper heating rates and conditions; and examination of the basic reaction mechanisms in the MSW gasification/pyrolysis. Liquid fuels research will include the identification and testing of catalysts that can upgrade MSW pyrolytic liquids.

The biochemical conversion program will use genetic engineering techniques to develop improved organisms with superior capability for hydrolysis and fermentation. An acid recovery system will be incorporated into the TVA test-bed facility for small-scale testing. The RefCOM Refuse to Methane Conversion test-bed facility will examine high solids loading of MSW in anaerobic digestion. The microbial populations responsible for methane production in sanitary landfills will also be investigated.

The regional program will continue its work in the Pacific Northwest, Southeast, Northeast, and Great Lake States regions, with greater cost-sharing by industry and state and local governments. Efforts will focus on defining the availability of resources within each region, and continuing to disseminate information and technical advice to potential users of biofuels technologies.

WIND ENERGY

The FY 1986 budget request for Wind Energy is $20 million in operating expenses and $.8 million for capital equipment. The research program outlined for FY 1986 focuses on meeting the technical challenges which reduce the risks associated with wind generated electricity.

Aerodynamics research activities will examine the fundamental processes resulting from wind forces acting on the turbine rotor. Major areas of emphasis include aeroelastic responses, blade loading, dynamic stall, and airfoil performance. Additionally, a program of cooperative research to use windfarms and other existing machines shall be undertaken to gather fundamental data on aerodynamic phenomena and to validate structural and aerodynamic models.

The structural research program will focus on the fundamental scientific and engineering principles that address materials stresses, component lifetime, and turbine dynamic interactions with the power grid that result from structural responses to the wind. The effect which wind turbine operations have on the utility network is also an area that requires further attention if wind technology is to achieve technical maturity.

The Wind Energy Research Center at the Solar Energy Research Institute continues to provide industry with analytical and experimental facilities to test prototype designs.

For FY 1986 final DOE funding is proposed to close the MOD 5B multi-megawatt turbine development project. Completed design and test data will be available for continued advancement of this technology by the commercial sector.

OCEAN ENERGY

The FY 1986 budget request for Ocean Energy is $3.5 million for operating expenses. The oceans are the largest collector and storage system for solar energy in the world. This energy is evidenced in the form of waves, currents, salinity gradients, and thermal gradients.

The strategy of the program is to focus on the technical uncertainties of 5-15 MWe size Ocean Thermal Energy Conversion (OTEC) near-shore systems. The FY 1986 program is predicated on this strategy and will lay the foundation for attaining OTEC system capital costs of $7200/KWe in five years, and $3200/KWe by the late 1990s.

Thermodynamics research activities will examine the fundamental issues associated with removal of noncondensable gases critical to the feasibility of open-cycle OTEC. There will also be research in waterside enhancement of advanced heat exchangers. Less expensive bonding and fabrication methods for these advanced heat exchangers will be addressed.

Cold water pipe research will be performed within the materials and structures activity area. Primary concentration will be on validation of computer programs for predicting loads, design, and performance.

Finally, in the experimental verification area, activities will focus on upgrading the Hawaiian Seacoast Test Facility. This facility, cost-shared by DOE and the state, will serve as the test bed for the ocean-thermal industry.

OTHER SOLAR ACTIVITIES

Recognizing the importance of transferring DOE R&D results to non-Federal sectors in an orderly and timely manner, FY 1986 funds are requested for $3.1 million in operating expenses for Solar Technology Transfer. Requested FY 1986 Program Support funds are designated for updating DOE solar and renewable energy multiyear technology R&D strategies, conducting ad hoc analyses, and providing for the continuation of technical and analytical services. In addition, funds totaling $2.3 million for general purpose equipment and 11 building and site improvement projects are being requested for the Solar Energy Research Institute.

A solar resources assessment initiative is requested for FY 1986, for $950,000 in operating expenses and $50,000 in capital equipment funds. Resource management, modelling, and measuring techniques are areas which will be investigated within this program element.

GEOTHERMAL ENERGY

When the R&D program in geothermal energy was initiated more than a decade ago, the only significant geothermal electric power generating source in the United States was the natural steam system at The Geysers in California. Today, geothermal energy uses have expanded to the production of electricity from eight reservoirs, and over 200 direct heat application facilities in several states.

The technologies for extracting geothermal resources vary widely, depending on the form in which they occur (steam, water, hot dry rock, or dissolved gas). The DOE Geothermal Program addresses these variations, with a balanced concentration between long-term, high-payoff research and R&D activities to assist industry in meeting nearer-term technical objectives.

The FY 1986 budget request for Geothermal is $24.7 million in operating expenses and $.5 million in capital equipment funding. This budget request emphasizes research activities to complement industry development initiatives. The program is focused on issues of technical uncertainty, balanced with efforts to transfer technologies that have significant energy potential in the upcoming years.

Hydrothermal research is planned to evaluate brine fluid handling, improve reservoir characterization techniques, and investigate binary cycle energy conversion and geothermal system materials. These activities will help expand the economically exploitable hydrothermal resource base.

Geopressured brines present issues significantly different from those of the hydrothermal resource. There is still uncertainty on the costs of drilling and completing wells in high pressure zones. Research in this area will involve well testing to establish long-term, high-flow rates. The reservoir testing program will also be used for cost-shared electric power generation experiments with industry.

The hot dry rock research will continue energy extraction experiments utilizing the very large man-made reservoir created over a year ago. The technology economics and longevity of a large scale reservoir must be determined before development of this geothermal energy resource will be considered by industry.

Magma, or molten rock, is the largest estimated geothermal resource and also the most difficult from which to extract heat. The technology required for extraction is still in the very early research stages. Materials for drilling equipment and heat exchangers must be identified. Geophysical measurements of selected sites will also be made to identify resource areas favorable for downhole experiments.

HYDROPOWER

Small-scale hydropower is a comparatively mature technology that uses the nation's streams and smaller waterways as an energy source to produce electrical power. The FY 1986 budget request for hydropower is $0.5 million which includes $0.45 million for technology support and $0.05 million for program direction. The DOE FY 1986 program provides the capability to monitor existing cost-shared projects and disseminate project engineering results.

GEOTHERMAL RESOURCES DEVELOPMENT FUND

The Geothermal Resources Development Fund was established to broaden the geothermal energy technology base by guarantying loans for private sector development of several state-of-the-art facilities. The FY 1986 request is $72,000 which allows for evaluating pending loan applications, restructuring existing guaranty agreements, and monitoring outstanding loans.

ELECTRIC ENERGY SYSTEMS AND ENERGY STORAGE PROGRAMS

The Electric Energy Systems and Energy Storage Programs provide vital linkages between energy supply, conversion, transmission, and end-use. The following are highlights of the proposed FY 1986 DOE activities in those technology areas, for which we are requesting a total of $26.1 million.

ELECTRIC ENERGY SYSTEMS

The Electric Energy Systems (EES) Program provides support for the continued research necessary to develop technologies and techniques for future electric energy supply and public health and safety. Specifically, the program is structured to: determine the biological health effects and risks to humans, plants, and animals exposed to high-voltage electric fields; provide technology options that will enhance the reliability of the nation's future electric network under all normal and emergency situations; and improve the efficiency of electric energy delivery systems through the development of new materials, advanced controls, and new design concepts. The FY 1986 request for EES is $10.0 million.

The electric field effects request is $3.0 million to continue research to establish an objective scientific data base for electric field effects. Efforts will continue to investigate the biological mechanisms at work to produce observed effects and develop a method to determine the impact of exposure to high-voltage d.c. systems and the inherent d.c. positive and negative ions resulting from electric fields on human respiratory systems and whole bodies.

A $3.0 million budget has been proposed for the Reliability R&D activity to continue research to assess the impact of a nuclear electromagnetic pulse (EMP) on the nation's electric network, to develop computer-aided technologies which will enhance power system performance during normal and abnormal operations, and to provide advanced techniques for control and protection of systems during major disturbances. For example, the response of the dielectric components of electrical equipment to waveforms such as those generated by lightning or switching surges is reasonably well understood. However, there exists limited information regarding breakdown phenomena when dielectrics are subjected to fast-rising pulses such as those generated by nuclear detonations. Current EMP-related research efforts include projects focusing on those features of nanosecond breakdown which distinguish it from processes occurring as a result of slower voltage changes.

Systems technology work in recent years has focused on technology development and equipment improvements which are of direct commercial interest and benefit to the electric power industry, and which should be substantially supported by EPRI and industry. The proposed budget for the Systems Technology research activity is $3.6 million. This budget level will be required to meet contractual obligations to terminate the current program, including the Athens automation and superconducting cable and generator projects, and contracts in the areas of high voltage direct current (HVDC) research, new materials, automation and processing concepts, failure mechanisms, and load leveling. DOE support for battery energy storage testing will be terminated and the facility and its equipment will be turned over to the Public Service Electric and Gas Company of New Jersey for continuing use by the electric power industry. A substantial amount of related but more long term battery work exists in the energy storage program.

Based upon program progress achieved thus far, the Hawaii deep water cable project will be more sharply focused. Previously appropriated funds will be used to complete cable design fabrication with test cable and laboratory tests. Research data and results will be made available to industry, technical libraries, and professional groups for future use. Sufficient funds are currently available to continue these efforts in FY 1986.

ENERGY STORAGE

The Energy Storage (EST) Program serves as the nucleus for virtually all research activities related to energy storage within the DOE. The major goal of the program is to develop advanced energy storage and conversion systems that will facilitate the use of abundant but intermittent energy sources and increase the efficiency of energy use with a concommitant benefit to the energy economy. The FY 1986 budget request for the Energy Storage Program is $16.1 million.

The Energy Storage Division is currently pursuing three promising categories of energy storage technologies: battery (electrochemical), thermal, and chemical/hydrogen. Of these, the largest investment has been in batteries because of their potential widespread use in transportation, load-leveling for electric utilities, general industrial energy storage, and as an integral part of renewable energy systems.

The $12.5 million Battery Storage activity consists of technology base research and exploratory technology development and testing, with the objective of providing the basis for improvements in existing battery systems and the identification and development of new batteries and fuel cells. Fiscal Year 1986 research activities are directed toward developing electrochemical energy storage devices with improved energy efficiency, lower capital cost, increased cycle life, and higher energy and power density.

In addition, the feasibility demonstration of the aluminum-air battery will continue in FY 1986. This program was initiated in 1979 and the first refuelable, multi-cell module was successfully tested in 1982.

The objectives of the advanced development and testing activity include development and evaluation of high performance, long-life, economical batteries for future mobile and stationary energy storage applications. In FY 1986, the exploratory technology development and testing activities will continue to concentrate on sodium-sulfur batteries as well as battery testing and post-test analysis of other batteries.

The Thermal and Mechanical Energy Storage activity is oriented toward providing the technical underpinning for the more effective use of thermal energy sources and improving the efficiencies of chemical/hydrogen production and storage. These technologies will permit energy conservation or fuel substitution in transportation and in residential and commercial buildings.

This $3.1 million activity will emphasize chemical/hydrogen research on high-temperature electrolysis and advanced storage options, such as refrigeration by adiabatic demagnetization, to achieve lower cost in hydrogen liquification. The thermal program will conduct research on form-stable phase change materials in the medium- and high-temperature range and explore advanced storage concepts and conversion techniques.

CONCLUSION

These energy conservation and renewable energy technologies show enormous potential for the future. Collectively, their potential applications make them highly attractive candidates for private sector development and deployment. These technologies promise increased energy supply diversity and end-use efficiency and should serve to promote increasing competition within the energy marketplace. Their development will also enhance the ability of the private sector to respond rapidly to unpredictable fluctuations in supply and price of fossil fuels.

The program presented for your review today represents a sound and stable commitment to the continuing development of these technologies. We are confident that our proposals will increase understanding of the potential for virtually all of the most promising energy conservation technologies and renewable energy options and will substantially contribute to the base of technical information required for informed decision making by industry and consumers.

Thank you for the opportunity to present our budget request.

Senator EVANS. Thank you very much for a concise review of a very complex and far-reaching program. I guess my first question is really with the budget constraints we are facing, do you feel—to what degree are any or all of the research into the things under your control constrained by the budget?

Ms. FITZPATRICK. Mr. Chairman, we think that we have been able to put together a budget request which preserves the core of the Federal research effort. We think that we have, although it is less than last year's appropriation, we think it supports everything that we think should be done by the Federal Government in advancing these technologies.

If I may, I can point out a number of places where our request is less than or more than what was requested and appropriated last year to give you an idea of how we are structuring our research.

Senator EVANS. I think it would be helpful to give, because that would give us some view of the relative importance you place on certain elements of research.

Ms. FITZPATRICK. All right. I'll run through a few of those things. There are also some areas where we have not made a request simply because we have projects that have been fully funded with previously appropriated moneys. One of those are the mine water and community systems work going on in the Pennsylvania. That's a total of about $3.4 million that we have not had to ask for this year. We have increased our requests for conservation technology transfer by about $1.4 million. We have increased our request for waste energy reduction work in the industrial programs field. In fact, the Industrial Energy Conservation Program has been increased in each of its areas, not only in waste energy reduction but also in industrial process efficiency, and in co-generation, and in the implementation and deployment line.

We have not requested funds for the Sacramento Municipal Utility District photovoltaic project or the Mod 5 wind turbine construction. We have not requested funds for the Stirling engine, and we do not require any funds for the high temperature materials laboratory at Oak Ridge simply because that has been fully funded and will be coming to completion in the next couple of years. They have broken ground on that and are having a preliminary dedication a little later this month, so that will not require any more substantial funds.

We are going to increase our work in biofuels. We are increasing our work in ECUT, energy conversion and utilization technologies, especially in the high temperature area.

So we have, we think, put forth a well thought out budget request which addresses what we think are the technical opportunities that exist to make a difference in our energy usage and production of energy from abundant resources.

Senator EVANS. Could you submit for the committee's records the original request made to the Office of Management and Budget for the various elements?

Ms. FITZPATRICK. Yes, we will.[1]

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[1] Retained in subcommittee files.

Senator EVANS. Let me, because it's so current, talk a little bit about transportation research. We spent this morning on hearings on the automobile fuel efficiency standards, and we had some considerable disagreement among the various automobile manufacturers as to what we ought to do.

What is going on? What appears to be the most promising new directions? To what degree is there association or coordination or cooperation in any of the Department's work with those of the major manufacturers in the drive to gain greater efficiency out of the automobile energy and drive chain?

Ms. FITZPATRICK. I think that all of our research programs are very, very closely integrated with the work of the automobile industry. They are, in fact, our major contractors and cost sharers in our development projects. Ford, Ford-Garrett, and GM-Allison are the two major teams that are working on two designs of the automotive gas turbine engine. Because they increased their cost sharing last year, we were able to continue with both of those designs rather than having to implement our original plan which was to have to make a choice between them last year.

They have been very supportive of this work. We are nearing now the point where we will be able to make some final decisions about where the Government role should lead in the future. Of course, there comes a point when the industrial parties would like to see us back out of it actually.

When they begin to get to the point where they want proprietary development and don't want to have to share everything that they're learning with us, and therefore, with their competitors, they will want us to let them go ahead on their own, and when that point is we are discussing with them. But that has certainly always proceeded with close industry cooperation and been dependent on them.

The same is true of the electric vehicle program which has been developed by industry, and also in the alternate fuels areas. We have the use of methanol. We are closely working with industry tc be sure that they are interested and that we aren't doing things that may be nice, elegant and esoteric solutions to problems but that nobody is interested in actually using and commercializing.

Senator EVANS. Do you have any feel at all as to progress in various aspects of these transportation—bits of transportation research? I guess one of those that you mentioned earlier but didn't expand upon was the whole use of ceramics as engine elements. How close are we to proven techniques, one that have some chance of entering the marketplace; and if we're close at all, what potential do they have in further increasing the efficiency of our automotive transportation?

Ms. FITZPATRICK. We have in the automotive gas turbine program fully ceramized engines. We have built the engines. They are being tested at higher and higher temperatures. I believe the gas turbine engines, without the actual turbine rotor, have actually been run at temperatures of more than 2000° Fahrenheit. Their full operating temperatures are in the 2300–2400° range, so there's still a ways to go. We will be expecting in 1986 to be testing those engines complete with the rotors, ceramic rotors at full temperatures.

We have seen already some spinoffs of applying these ceramics to other uses and technologies, and I would expect to see a great deal more of that. We are also proceeding with the design of the adiabatic diesel engine for heavy truck transportation.

If these research products succeed and are picked up by industry and made into commercial products, we should have automobile and truck engines that are approximately 30 percent more efficient than what we have today. We should be able to cut our petroleum usage for transportation, which of course is the bulk of our current use of oil derived fuels—most of our petroleum is used for your road transportation. We should be able to cut that substantially.

Senator **Evans**. And that 30 percent, that's an estimate that I would presume is perhaps even on the conservative side?

Ms. **Fitzpatrick**. That's on the conservative side, yes.

Senator **Evans**. How—what time period would you estimate that we might get to the point where we can prove that out or have it available?

Ms. **Fitzpatrick**. Well, I would hope to see some commercial vehicles available in the early 1990's.

Senator **Evans**. On industrial conservation you do have, as you pointed out, an increase across the board. I guess the first question is what do you—how do you interrelate any of your R&D development work within the Department with some of the work—I'm not sure you'd really categorize it always as R&D work, but for instance, some of the work that Bonneville is doing in seeking out additional residential, commercial and industrial conservation techniques? That budget that they are using is outside of the budget that you're now talking about, I would presume.

Ms. **Fitzpatrick**. That's correct, Mr. Chairman.

Senator **Evans**. How much correlation or cooperation is there between, say, Bonneville, TVA, other Federal agencies and your Department?

Ms. **Fitzpatrick**. What we are doing is fairly basic research, which is trying to develop technologies which will become available to utilities and to their customers. I think what Bonneville and other utilities are doing is letting their customers know what is already available to them, what they can do and find available in the marketplace today to improve their energy efficiency. So they are picking up past the point where we are leaving off for the most part. We certainly are aware of what they're doing, and we try to keep everyone who has an interest aware of what we're doing.

Senator **Evans**. One of the techniques that it seems to me has the potential of being very successful is where instead of offering proven or suggested proven techniques to industry to utilize, there is an offer made or could be made say to industry saying we will buy anything you can give to us in industrial conservation at $1,000 per installed kilowatt or some reasonable price that is cheaper than the alternative sources of energy those utilities might seek, and let the industries come back with their ideas, and their programs, and their research to achieve those end results.

Is that something that ought to be confined just to Bonneville, or is that a method of approach that would be useful in other areas as well?

Ms. Fitzpatrick. We think that is something that all utilities should be considering, and in fact, we have in our Building Energy Office's technology applications line item a new request of about $400,000 to help us make utilities more aware of that kind of opportunity. Very often they can in a sense buy conservation for less than it would take them to build new capacity, and we think that is a very, fruitful line for them to follow.

Senator Evans. I'll defer to Senator Bingaman for the moment. I have a few questions after that.

Senator Bingaman. Thank you. Thank you, Mr. Chairman.

Let me just start out with some very general questions since I'm new to this committee.

I notice there is a decrease in requested funding from last years levels for conservation and renewable survey programs. Is there a trend over the last 4 or 5 years in this same direction, or is this a reversing of the trend? Have we been decreasing our funding in real terms for these various research efforts?

Ms. Fitzpatrick. Overall, the appropriation and the requests also have been trending downward. However, the real research has been level or increasing. What we have been trying to do for the last several years is weed out some rather expensive items that are not truly research but are more demonstration projects. They don't do anything to actually help the advancement of a technology, but they are implementations which might be valuable but we think is probably not in most cases the province of the Federal Government to finance.

So if you actually look at the true research going on in our budget, that has been level or increasing.

Senator Bingaman. That has been going up you say?

Ms. Fitzpatrick. Yes; there are cases where that is going up, and for the most part it has been going up.

Senator Bingaman. In the case of photovoltaic research, I notice there's a significant decrease from 1985 appropriation in this program. Let me ask, is this a trend which exists over several years? Have we been decreasing our support for research in photovoltaics?

Ms. Fitzpatrick. I think the major point of decrease from the 1985 appropriation is about $9.5 million that we are not recommending be appropriated for the Sacramento Municipal Utility District project, which in fact has been abandoned by the utility district. They are not proposing to continue with it, and we didn't think that it was worth our funding either.

I think otherwise our photovoltaic budget is very strong, and we are supporting that very strongly.

Senator Bingaman. I was in Japan in January and met with some of the people at MITI, and they seemed to have a very aggressive research effort going forward on photovoltaics in order to bring the per unit cost down to a level that they could be commercially very attractive.

What is your estimate as to when photovoltaic cells or this research will be applicable or usable and available in the commercial market in the United States on a basis that makes sense for the average consumer?

Ms. Fitzpatrick. I've watched the history of energy predictions for some years, Senator, and they're always dangerous. What we're trying to do in our program is to bring the cost, the initial cost of a system down, to increase the efficiency of the systems and to increase the reliability and longevity. We need to have systems that will last 20 or 30 years.

There are available on the market today photovoltaic products as consumer items, mostly for remote area applications: battery rechargers for campsites or mountain homes, off-grade applications for communications devices, irrigation pumps and that sort of thing. So photovoltaics are already economically viable for special niches of the market.

We would expect to see an increase in that steadily over the next few years. It's very difficult to predict, but we would expect to see in the 1990's major penetrations by photovoltaics into consumer products, home applications and increasing use by electric utilities. We already have megawatt-sized grid arrays being installed by utilities and hooked up to the grid, and we're going to see, we think, that trend continuing.

Senator BINGAMAN. Based on your knowledge of the level of effort that we're making in this research and the level of effort that the Japanese are making, who do you expect to capture that market in the early 1990's that you're talking about?

Ms. FITZPATRICK. We expect that we will, Senator.

Senator BINGAMAN. You believe that we will?

Ms. FITZPATRICK. Yes; I believe that the Japanese have been very impressive in their volume of penetration of the market. However, that has been based very largely on really rather low tech cells, amorphous silicon cells which are cheap, easy to make but not very efficient. They've captured the consumer product market, for example, where they will put a cell on a wristwatch or a handheld calculator.

I might add we lost those two particular markets to the Japanese some years ago, and here they are now exploiting them in a totally unrelated fields, photovoltaics, or previously unrelated field.

We think that we have the technological edge, that we are making advances in multi-junction, very high efficiency cells using new types of semiconductors that will give us the best available on the market, both in the United States and in the world market, and that we're making very substantial progress.

Senator BINGAMAN. Now, in my home State of New Mexico there is a highway sign on Interstate 24 from Albuquerque to Santa Fe that is powered by a photovoltaic cell and it's made by Kiasara in Japan. And my understanding was that when the decision was made to use this cell, we found that it was not available in this country and that's why it was bought from the Japanese.

Is that one of the low tech items that you would refer to, and how does that square with your assessment?

Ms. FITZPATRICK. Our understanding is that that was a bid process, that the technology was available in this country but the Japanese got the lowest bid and, therefore, they got the job.

Senator BINGAMAN. I see.

Senator EVANS. I, maybe, should add to my colleague that Kiasara is now housed and building a major plant in the State of Washington, so I guess they're at least semi-domestic.

Senator **Bingaman**. Well, I'm not casting any aspersions on your constituents, Senator. I didn't want to be interpreted as doing so. I'm very impressed with the work that they're doing. I'm just very hopeful that we are doing equally as fine work and that in fact we will be able to capture this very important market that I see becoming available.

Let me ask what your thought is on this a new tax package from the administration, which I gather from newspaper accounts will not include a suggestion that we continue the solar energy tax credit. Is it your view that that is consistent with what you're trying to accomplish?

Ms. **Fitzpatrick**. Well, our policy for the last year has been that solar energy tax credits have been very beneficial for the energy, have helped an infant industry begin to make progress. We have also understood that all of those benefits have to be weighed against the money and other considerations that go into making a total tax reform package.

I want to see energy tax credits included. I also understand that there are competing interests. We'll have to wait and see what finally comes out of the Treasury.

Senator **Bingaman**. Again in my home State I noticed a lot of television ads for people to go out and buy solar hot water heaters and other types of solar energy devices that are being advertised on the basis that this tax credit will be eliminated soon, and, therefore, people better get in and buy them if they want them.

Have you conducted any study or had any way to estimate the effect of eliminating that tax credit on the solar energy equipment industry, if that's the right term, for the people who make these, make and sell these solar hot water heaters and other solar devices?

Ms. **Fitzpatrick**. We don't have a formal study that we've done at the Department of Energy, Senator. I understand that, of course, the industry has made some projections. Various States, I also understand, have done some studies. In general, you would have to guess that it will not help the industry to have the tax credits eliminated. It certainly gives them a disadvantage. Exactly what will happen is hard to predict. There will probably be some, what's usually euphemistically called, restructuring within the industry.

Senator **Bingaman**. We've had a lot of that in our State. The copper industry's been restructured and a few others.

Ms. **Fitzpatrick**. Yes. It's hard to say what the dollar impact will be. A lot depends on simply what happens to other prices. Are oil prices going to continue to go down or stay steady, or will they begin to climb again? All of those things have an impact on it. Regional costs of electricity, for example, is something that many homeowners will have to look at closely because they'll be talking about replacing electricity or natural gas if they put in solar installations.

Senator **Bingaman**. I guess the bottom line is you think that it will not have that adverse an effect on the industry to take this tax credit away?

Ms. **Fitzpatrick**. No; I wouldn't say it exactly that way. I don't know what the effect will be. I expect that it will be adverse. It's difficult to say how severe it will be.

Senator **Bingaman**. Mr. Chairman, I have a series of other questions and a statement I wanted to put in the record, and maybe I could ask the Secretary to respond to the questions. I don't want to take more of your time here, but I very much appreciate her testimony.

Senator **Evans**. Fine. And we will add your full statement into the record.

[The prepared statement of Senator Bingaman follows:]

STATEMENT BY SENATOR JEFF BINGAMAN
FY 86 Department of Energy Authorization
Hearing--Conservation and Renewable Energy Programs
May 14, 1985

Renewable energy development must be a priority of a national energy policy if we are to be prepared to meet the challenges of the next decade. We have become complacent in recent years as our energy situation has improved from the chaos of the 70's. The recent oil glut has taken energy problems out of the public eye and off the administration agenda. However, we cannot ignore the fact that our dependence on foreign sources of oil will double by 1995. We must take action now to prepare for potential supply disruptions at that time. If we learned nothing else from the embargo of the early 1970's, we learned how fragile our economy is and how reliant we are on imported energy from unstable foreign sources. It is up to us to develp alternative energy sources before we face another crises.

Renewable Energy must play a major role now to protect us from a repeat of the 1970's.

The development of renewable energy has become an important success story in our nation. Since 1978, energy use in the U.S. has fallen 10 percent, oil consumption has dropped 20 percent. This has been due primarily to increased energy efficiency in our economy. However, renewable energy sources have a major role to play in this more efficient economy. Since 1979, the renewable share of the energy supply has increased from 6 to 9 percent. Wood fuel and hydropower have accounted for most of the growth in renewable energy reliance in the past decade. However, the most important advances made in renewable energy are not yet visible on natural energy charts. They soon can be with continued assistance.

According to the recently published "Renewable Energy at the Crossroads," windpower installations are doubling each year and now exceed 8,000 machines, photovoltaics output rises 50% annually, and alcohol-blended fuels will soon supply over 10% of the automotive fuels market. Additionally there are significant advancements in hydropower, biomas, geothermal, ocean thermal energy systems, and solar heating and cooling systems.

The private sector has stepped up investment in renewable energy, taking up some of the slack from dwindling federal programs. But it is a productive public-private partnership that has brought the renewable energy industry to the economic crossroad it has reached today.

The biggest boost for the renewable energy industry in the early eighties has been the renewable energy tax credits.

They have spurred investments in solar, wind and biomass technologies in particular. Unfortunatly, this support is in jeopardy as the credits expire at the end of this year. The renewable energy tax credits represent the only significant remaining targeted federal incentive for renewable energy development. Our energy supply and our economy are not so strong that we can afford to eliminate them.

Either lack of funding or continuation of improper renewable energy incentives could severely damage the prospects for the industry. We cannot afford to provide inadequate support to an industry our government has carefully nurtured to the point of economic viability with modest but effective support, the country can move along the path toward a sustainable energy system and a renewable energy industry that is second to none.

QUETIONS FOR DONNA FITZPATRICK

FROM SENATOR JEFF BINGAMAN

DATE MAY 14, 1985

1. The Energy Information Administration, in their annual Energy Outlook, estimated that our dependence on foreign sources of petroleum will double by 1995. Given these projections, do you think we are devoting enough attention to renewable energy technologies? I am concerned about the trend in this administration to reduce the emphasis placed on these important programs. Can we afford as a nation to reduce our commitment to providing the best possible energy mix to meet our future needs?

2. I understand we have made significant progress in many renewable technologies including geothermal and solar. However, faced with shrinking federal dollars, how can we continue to ensure continued progress in these areas?

3. What are the Administration's long range goals for these renewable programs? Does the Department of Energy have a commitment to continue support for renewable technologies as long as progress can be demonstrated?

4. Do you really think the private sector can achieve the same significant progress in the alternative energy areas that we have had thru federal support?

5. We know we are increasing the percentage of our energy requirements supplied by alternative energy sources. What type of reporting system is there to keep track of this increased contribution? Can these systems be improved?

6. I am concerned that the Department has underestimated renewable energy's current contribution and future potential. I think it is one of our most promising growth industries. What action have you taken to provide for the dissemination of information on these technologies? Can we improve our PR efforts related to alternatives in order to increase public awareness and interest?

7. I am particularly concerned about ensuring that the results of our basic research efforts in this area are transfered to the private sector for commercialization. What mechanisms and/or programs does DOE have to accomplish this?

8. I am concerned with reduction in the Hot Dry Rock Program carried on at Los Alamos. With the budget you have recommended, what happens to the International Energy Agency Agreement regarding Hot Dry Rock research?

9. Is the department committed to the development of fuel cells for transportation purposes? I am particularly interested because I understand General Motors is willing to cost-share at the 50% level with the government for such an effort. What is your level of commitment in terms of budget resources?

Senator EVANS. Let me just continue in one other field. I think you know from previous conversations of my curiosity, I guess is the best term to use, about hydrogen as a potential entry in this renewable energy race, but the fact that we're not putting very much into that kind of research. Is it your view that the problems just are too overwhelming, or should we be spending more? Does it have any potential value? Where does it rank in the whole range of things, in your view?

Ms. FITZPATRICK. Well, Mr. Chairman, I think hydrogen is attractive as a fuel because it burns cleanly, and turns to water, of course, although you get other pollutants such as nitrogen oxides that are produced. The problem is that hydrogen doesn't occur as an element, a free element in nature.

Therefore, in order to get a fuel, you have to separate the hydrogen from something else, an acid or water itself. That means that you probably—you don't have a net energy gain from burning hydrogen. You're going to have to use as much energy to get it out, get it separated from the oxygen as you gain when it reoxidizes. Hydrogen, therefore, is really not so much a fuel as an energy storage and transmission device. You would use it where you would want to have a gaseous fuel which could be useful perhaps in transportation. At the moment the usefulness or promise of hydrogen really is very much dependent on the cost of electricity, since electrolysis is the way that we produce it for the most part, or would be the way of producing it in bulk. And the cost of electricity at one time, of course, was supposed to be very cheap. We were going to have electricity from nuclear power that was too cheap to meter, and at that time people we're thinking great, now we can make a gaseous fuel, hydrogen, which we can use in places where electricity is not convenient. That hasn't happened, and whether it will happen at some point in the future is a problem.

I think that hydrogen is not something that we should write off. We are continuing to try to find efficient and economical ways of generating hydrogen, either from acids or from water, and that is the point of the research that we are carrying on. We don't see it as a particularly near-term fuel. We do see it as a long-term option.

Senator EVANS. Are we doing sufficient research along that line to give it a full shot, a full chance?

Ms. FITZPATRICK. Yes, I think we are. Our office is doing some. The Office of Energy Research, Basic Energy Sciences Division is doing some. We have regular coordination between the programs to be sure that we're not duplicating or missing anything. And I think that the effort at present is sufficient.

Senator EVANS. Do you foresee the potential sometime in the future if we are—if we are able to bring photovoltaics down to the point where they really are competitive or more than competitive perhaps—and it seems to me there is a chance of doing that. We know the process, we're talking about greater and greater efficiencies, and it seems to me we're almost at the beginning of the learning curve in that technique.

Would that offer us the potential of a combination of the energy source necessary to convert, as you say, water into hydrogen and that combination also offer the potential for some extremely portable, useful, replicable kind of hydrogen generating plants which could be used almost any place in the world?

Ms. FITZPATRICK. Well, if photovoltaics could get cheap enough, that would certainly be a very attractive option.

Senator EVANS. What about in the general nature of international cooperation? Is the network operating as well as it should to ensure that scientific endeavor in one part of the world is hooked up with similar endeavors going on here?

Are you satisfied with that kind of effort?

Ms. FITZPATRICK. Mr. Chairman, that's been a matter of a good deal of discussion, especially within the International Energy Agency. We are meeting constantly and in fact all the ministers of the member countries will be meeting this summer, and that is one of the items on their agenda.

There's been some feeling that the management of international cooperative research projects has gotten too cumbersome and needs to be streamlined. We are pursuing a number of bilateral agreements with various nations where we are studying one another's research programs and looking for collaborative research areas that either we are both working on where we could combine our efforts or areas that we would both like to work on where we could combine our efforts so that there is a mutually beneficial joint project.

I think that holds a great deal of promise. Simply the process of exchanging information before you could determine what a collaborative project might be has been very beneficial. We also have a large number of countries who in the last few years have asked for access to the energy data base which the Department of Energy maintains at Oak Ridge, Tennessee. And we have a number of bilateral agreements with various nations.

This morning, as matter of fact, Secretary Herrington and Secretary Walker from the United Kingdom signed an agreement whereby the United Kingdom becomes a participant in that energy data base.

So this is an ongoing effort. We recognized that things probably were getting a little too cumbersome, and we are exploring with each country that's interested how we can best cooperate with them.

Senator EVANS. I know I was interested—I was in the Middle East a month ago, and Israel seems to have done some very interesting things, are in the process of doing some very interesting things, especially in relation to various uses of solar energy. In fact, I'm getting some of the information that they're sending off to me on some processes that sounded—at least they were unique as far as I had heard, and I presume they are known to those of us here. But they have some advantages that we don't have in certain parts of our country like 350 days of sunshine.

Ms. FITZPATRICK. They have some disadvantages we don't have either.

Senator EVANS. That's correct.

Ms. FITZPATRICK. We had an extensive series of meetings and exchanges of experts last year. We are continuing that this year. In fact, there's a U.S. delegation going there next month, so we have continuing contacts with Israel.

Senator **Evans**. Well, thank you very much. It's been a very interesting exchange, and we look forward to the potential. I can't think of any place in the Federal Government that has anything to with energy that potentially has more promise than what's going on here.

Ms. **Fitzpatrick**. Thank you, Mr. Chairman.

Senator **Evans**. The public witnesses are Mr. Gregory Franta, Chairman of the Energy Committee, American Institute of Architects, and Mr. Lloyd Lawerence, Director of Technical Development, Mechanical Technology of Latham, New York.

If you gentlemen would come forward.

Please go ahead, Mr. Franta.

STATEMENT OF GREGORY FRANTA, CHAIRMAN, ENERGY COMMITTEE, AMERICAN INSTITUTE OF ARCHITECTS

Mr. **Franta**. Mr. Chairman, my name is Greg Franta. I'm principal architect of the Ensar group in Lakewood, CO. It's an architectural and energy consulting firm. And I'm pleased to present the views of the American Institute of Architects on energy conservation and solar buildings research programs of the Department of Energy.

The AIA is a professional association representing the Nation's architects, and I am the chairman of our national Energy Committee. My testimony today concentrates on several DOE programs under the building and community system programs and under the solar buildings research programs. My purpose is to indicate what research activities and accompanying funding levels will best aid architects in providing the most energy efficiency building designs.

In general, our recommendations for both research areas derive from several principles we consider fundamental to a successful energy conservation and solar research effort. We believe that DOE's research funds should support activities that the private sector cannot undertake on its own. Not only does this further the proper role of Government, but it also increases the total research product available.

In connection with this, we also favor the examination of the energy performance of building components in relation to one another rather in isolation. We also believe in technology transfer activities that utilize the strengths of existing organizations and associations to pass the research result to practitioners in the field.

We favor new emphasis on research of commercial structures because of their complexity, and we believe that in developing its research programs in these areas, DOE should consult with practicing architects to benefit from their experience.

In making these recommendations the AIA is fully cognizant of the critical need to reduce the Federal budget. In furtherance of this national interest, we recommend that the 1986 appropriations hold to the current level of funds for building and community systems and for the solar energy research areas.

Within each program area we recommend increases in certain line items to reflect our sense of priorities. We would expect, therefore, reductions in other line items to compensate for the proposed increases.

In the interest of brevity I would like to emphasize a couple of specific areas of my prepared testimony. First is on the commercial building systems interactions. The AIA has accorded the highest research priority to building systems interactions or, as we call it, whole buildings research.

For fiscal year 1986 we support the administration's funding level for residential buildings. We believe, however, that $1.7 million should be provided for the commercial buildings aspect of whole buildings research for the next five years.

The priority that we place on whole buildings research stems from our belief that the greatest amount of energy can be achieved through understanding how a building—how buildings components perform in relation to one another rather than in isolation. Only sophisticated analysis that compares one building design strategy to another and takes into account the relationships among components while assessing the overall performance of the total system can provide architects with the information needed for application to everyday practice.

A great deal of private research is already occurring on individual building components, much of it supported by private product materials manufacturers. At the same time, because whole buildings research can be quite expensive, costing more than $700,000 for a single study, it lies beyond the reach of architectural or development firms. Such research also lies beyond the interest of private manufacturers who prefer to spend their time and money on improving their own product lines.

Meanwhile, whole buildings research is progressing very slowly. Of 17 separate building types only 2, office buildings and manufactured housing, have been the subject of completed studies. At the current rate of study it will take 15 to 20 years to complete the study of all significant building types.

Under analysis and technology transfer, this year the administration requests $3.4 million for a combined technology transfer and research utilization program in place of the programs that are currently separate. Included in the DOE proposals are funds to establish several energy efficient building centers and a fellowship program of 8 persons at $50,000 each. Congress rejected a similar recommendation last year, and we urge the same action for this year's version.

We also oppose the consolidation of the research utilization program with the technology transfer function. DOE's plans would actually diminish the dissemination of technical research information to professionals in the field. We have serious doubts that the construction industry and design professionals would use the proposed center and cannot see the justification for individually expensive fellowships when other activities may offer much greater value.

We believe that technology transfer funds should be used to work with existing organizations and associations to help them relate research data to their members, produce consumer information, educate the financial community about the benefits of conservation, and conduct seminars and briefings for State and local government agencies. We feel that these functions can be accomplished through $1.5 million in appropriations. The research utilization program should remain distinct from technology transfer and receive $1 million in appropriations.

Under solar buildings research, AIA has a particular interest in passive solar research activities because of their greater implication for building design. AIA believes that three areas of passive solar research deserve highest priority: aperture materials, systems integration, and technology transfer.

The AIA supports $1.45 million for the aperture materials line item, which is $900,000 more than provided in 1985. We place a high priority on this research aspect because it will produce the materials necessary to develop new types of glazing systems and coatings for windows.

This area has more potential for a major breakthrough and will provide a greater contribution for solar application than thermal energy storage research, which the administration plans to increase.

Under systems integration, the AIA agrees with the administration's overall request for $4.1 million for systems integration, but we would apply slightly more to the nonresidential buildings aspect of this research.

And under technology transfer we have recommended $900,000 for this solar program. Unfortunately, the administration prefers not to fund this program at all. AIA thinks that this is a mistake because it would greatly interfere with the dissemination of information about government-sponsored research.

Mr. Chairman, that concludes my testimony.

[The prepared statement of Mr. Franta follows:]

THE
AMERICAN
INSTITUTE
OF
ARCHITECTS

1735 New York Avenue, N.W.
Washington, D.C. 20006
Telephone: (202) 626-7300
Cable Address: AMINARCH
Telex: 710822 1112

STATEMENT OF

GREGORY FRANTA, AIA

ON BEHALF OF

THE AMERICAN INSTITUTE OF ARCHITECTS

BEFORE THE

ENERGY RESEARCH AND DEVELOPMENT SUBCOMMITTEE

OF THE

ENERGY AND NATURAL RESOURCES COMMITTEE

OF THE

U.S. SENATE

MAY 14, 1985

ENERGY CONSERVATION AND SOLAR BUILDINGS RESEARCH PROGRAMS OF THE DEPARTMENT OF ENERGY

TESTIMONY BEFORE THE U.S. SENATE SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

Mr. Chairman and members of the Subcommittee, my name is Gregory Franta, AIA, a principal in the Ensar Group, an architectural firm in Lakewood, Colorado. I am pleased to present the views of the American Institute of Architects on energy conservation and solar buildings research programs of the Department of Energy. The AIA is the professional association representing the nation's architects. I am Chairman of the AIA's Energy Committee.

The AIA is grateful to you, Mr. Chairman for your interest in energy conservation and renewable resources, and commends you for holding this hearing today to encourage public discussion of these important issues.

My testimony today concentrates on several DOE programs under the Building and Community Systems programs, and under the Solar Buildings Research programs. My purpose is to indicate what research activities and accompanying funding levels will best aid us as architects in providing the most energy-efficient building designs.

The AIA's public policies strongly support conservation of fossil fuel. Energy savings increase our country's ability to maintain adequate energy supplies to preserve national security, power our industry and commerce, and provide comfort in our homes and workplaces. Reducing non-renewable energy use also enhances the quality of the environment. The AIA has backed up its public policies with direct investment of Institute funds to promote the benefits of reducing consumption of fossil fuels through improved building design. Our expenditures include about $2 million for an energy education program called "Energy in Architecture" which is a workshop serier that increases the proficiency of our members in energy design.

Buildings are significant points of energy end use, and thus they can be a principal contributor to energy savings. About 37 percent of the nation's energy use occurs through buildings, about forty percent of which is attributable to non-residential buildings. Our experience tells us that today's building designs are far more efficient than they were five years ago. According to DOE's own research, a building's energy use can be cut by as much as 40 percent when efforts are made to use the most efficient and cost-effective design measures available. This applies also to solar design. As the 1984 DOE report states, "a well-designed and well-integrated passive solar building is expected to use no more that 50 percent of the energy used by a similar conventional building."

The practice of architecture and energy conservation go hand in hand. As architects, it is our job to provide our clients with building designs that combine grace and form with function and performance, and in striking this balance to answer our clients demands for energy efficient structures--whether the clients come to us as homeowners, corporations, or governments. To provide the best service, we must know of the latest research results and how to apply them. Thus, it is clear that the energy conservation and solar buildings research programs under your Subcommittee's jurisdiction directly affect our ability to obtain the greatest energy savings through building design.

The recommendations I offer today comprise what the AIA believes will best produce the research results that architects will find most useful in their daily practices. My testimony is divided into two general sections--selected programs under the Buildings and Community Systems programs and selected programs of the Solar Building Energy Research program. Under the former, we direct the Subcommittee's attention to the following line items: commercial building systems interaction, performance monitoring, design process research, analysis and technology transfer, research utilization, and indoor air quality. For solar buildings research, we have concentrated on aperture materials, systems integration, and technology transfer.

In general, our recommendations for both research areas derive from several principles we consider fundamental to a successful energy conservation and solar research effort. We believe that DOE's research funds should support activities that the private sector cannot undertake on its own. Not only does this further the proper role of government, but it also increases the total research product available. In connection with this, we also favor the examination of the energy performance of building components in relation to one another rather than in isolation. We also believe in technology transfer activities that utilize the strengths of existing organizations and associations to pass research results to practitioners in the field. We favor new emphasis on research of commercial structures because of their complexity. And we believe that in developing its research programs in these areas, DOE should consult with practicing architects to benefit from their experience.

In making theses recommendations, the AIA is fully cognizant of the critical need to reduce the federal budget. We have endorsed a balanced budged through our own convention resolution and through a coalition of 32 national organizations primarily devoted to financial and construction concerns.

In furtherance of this national interest, we recommend that FY 1986 appropriations hold to the current year levels for building and community systems and solar energy research areas. We endorse these funding levels not because they represent what we believe is necessary. In fact, they do not even come close. Rather, we support these amounts as a balance between the high priority of energy conservation and solar buildings research and the equally high priority of progress toward a balanced budget. We hasten to add that we would strenuously oppose any reduction below the FY 1985 level, which is already substantially less than for the previous fiscal year. Solar energy research, for example, dropped 40 percent from FY 1984 to FY 1985. Within each program area we recommend increases in certain line items to reflect our sense of priorities. We would expect, therefore, reductions in other line items to compensate for the proposed increases.

I would now like to offer specific funding recommendations for each of the program areas, and reasons for these recommendations.

BUILDING AND COMMUNITY SYSTEMS

Commercial Building Systems Interactions

The AIA has accorded the highest research priority to building systems interactions, or "whole buildings research". We were gratified when the Congress supported $2.45 million for this research area for both residential and commercial studies for FY 1985. For FY 1986, we support the Administration's funding level for residential buildings. We believe however, that $1.7 million should be provided for the commercial buildings aspect of whole buildings research for each of the next five years. Whole buildings research has won widespread recognition, including two awards from the distinguished Progressive Architecture magazine.

The priority that we place on whole buildings research stems from our belief that the greatest amount of energy savings can be achieved through an understanding of how a building's components perform in relation to one another, rather than in isolation. Buildings are much more than the sum of their parts. They function as dynamic, complex technical systems.

We believe that DOE's research program to date has placed too much emphasis on the study of individual building components, to the neglect of systems interactions. Last year, in fact, the Department proposed terminating the whole buildings research program altogether. Congress wisely rejected this idea. Only sophisticated analysis that compares one building design strategy to another, and takes into account the relationships among components while assessing the overall performance of the total system, can provide architects with the information needed for application to everyday practice.

A great deal of private research is already occurring on individual building components, much of it supported by private product and materials manufacturers. At the same time, because whole buildings research can be quite expensive, costing more than $700,000 for a single study, it lies beyond the reach of architectural or development firms. Such research also lies beyond the interests of private manufacturers, who prefer to spend their time and money on improving their own product lines. Meanwhile, whole buildings research is progressing very slowly. Of seventeen separate building types, only two--small office buildings and manufactured housing--have been the subjects of completed studies.

The whole buildings research program has also embarked on the examination of multi-family housing types and plans to look at retail facilities with its FY 1986 appropriation. We agree with this program direction, emphasizing however, that the pace is too slow. At the current rate of study, it will take fifteen to twenty years to complete the study of all significant building types.

The AIA believes that the federal government has no business undertaking what the private sector is able to do, and is apparently doing for itself. Rather it should direct its inquiry toward those research concerns that the private sector is unable or has no motivation to pursue.

As part of its whole buildings program, DOE plans to continue the joint AIA/ASHRAE work on the voluntary energy targets effort. This work will result standards, and will use the voluntary consensus process to arrive at standards that are at once state-of-the-art and acceptable to private industry. These voluntary performance targets will provide architects and their clients with much needed objectives that are clear, attainable at reasonable cost, and without specification of the methods or materials to be used. The flexibility afforded by performance standards is essential to effective voluntary compliance.

Performance Monitoring

Performance monitoring should be increased to $800,000 from the $400,000 allocated for FY 1985. This activity involves the monitoring of energy performance in actual buildings. DOE has established monitoring devices in seven restaurants and six office buildings, and should expand this project to include offices in hot/humid climates.

The data base on commercial buildings funded through the Battelle Pacific Northwest Laboratory should be continued in addition to the FY 1986 program envisioned by the Department. In addition, Brookhaven National Laboratory should be encouraged to continue and expand its programs in the area of monitoring metal buildings used for a variety of non-residential purposes. These types of buildings have accounted for more than half of new low-rise nonresidential construction in recent years, and are a significant part of the existing building stock.

Design Process Research

The AIA urges an increase in the Department's program of design process research from $100,000 to $250,000 for FY 1986. The most significant energy savings can be achieved during the design phase of a building's development, before the components are fixed in place. It makes sense, therefore, to examine the building design process itself to determine the extent to which lessons can be derived and applied throughout the profession to make the process more energy-conscious. While the AIA applauds the Administration for proposing this important research project, the amount recommended is insufficient. In our view, DOE's proposed amount would allow enough to plan the project, but not enough to carry it out. Because the study will require teams of architects in the field working with architectural and engineering firms as they undertake their projects, observing them at their tasks and analyzing these observations, we believe that an additional $150,000 is necessary for FY 1986.

Analysis And Technology Transfer

In order for architects to take advantage of the design process to achieve energy savings in their projects, they must have information on energy saving options, while they are still determining building size, shape, orientation, and internal configuration. If it were directed toward transferring research results to practitioners in the field, DOE's technology transfer program could provide that information.

This year, the Administration requests $3.4 million for a combined technology transfer and research utilization program, in place of the programs that are currently separate. Included in the DOE proposal are funds to establish several energy efficient building centers and a fellowship program of eight persons at $50,000 each. Congress rejected a similar recommendation last year, and we urge the same action for this year's version. We also oppose the consolidation of the research utilization program with the technology transfer function.

DOE's plans would actually diminish the dissemination of technical research information to professionals in the field. We have serious doubts that the construction industry and design professions would use the proposed centers and cannot see the justification for individually expensive fellowships when other activities offer much greater value. We believe that technology transfer funds should be used to work with existing organizations and associations to help them relate research data to their members, produce consumer information, educate the financial community about the benefits of energy conservation, and conduct seminars and briefings for state and local government agencies. We feel that these functions could be accomplished through $1.5 million in appropriations.

The research utilization program should remain distinct from technology transfer and receive $1 million in appropriations. It differs from technology transfer in that it provides ongoing informational services, not only informing architects and others of the availability of important research data, but also aiding them in applying the research. Products that they can use in their everyday practice involve written materials, trade journal articles, visual and auditory aids and training sessions and workshops. Research utilization also has provided the opportunity for design competitions for architectural students, and an institute for architectural and engineering schools, both worth-while activities that should be continued.

Indoor Air Quality

As we search for ways to conserve energy in buildings we must be mindful of the need to protect the quality of indoor air. Research on indoor air quality should receive an appropriation of $2.5 million, $600,000 above the FY 1985 level. The nation has become increasingly aware of serious problems with the quality of air in homes and workplaces. Urban residents typically spend as much as 90 percent of each day indoors, making them dependent on properly functioning HVAC systems and on building designs that recognize the importance of air exchange. Excessively tight buildings seeking reductions in energy consumption, along with ill-advised interior alterations to original architectural features and imbalanced HVAC systems have led to increased levels of some pollutants above accepted air quality standards. In a number of instances, the poor quality of indoor air has caused serious health problems. The National Institutes of Occupational Safety and Health have investigated over 200 commercial buildings where the air quality has made occupants ill. Both biological and chemical culprits have been at work in mishaps traced to indoor air pollution, and scientists are growing increasingly aware that individual pollutants reacting to one another in the air may create effects on health that surpass those of individual pollutants acting separately.

The list of pollutants ranges from passive tobacco smoke, bacteria, and carbon monoxide to radon decay products, formaldehyde, and asbestos fibers.

Indoor air quality research is at a nascent stage, and information is "fragmented, anecdotal, and often contradictory," according to John Spengler and Ken Sexton writing in the July 1983 issue of Science magazine. They state that "a strategy should be developed to ensure a coordinated, well-managed investigation of indoor air pollution exposures and their health consequences." The call for such a strategy was recently echoed at an inter-disciplinary conference on indoor air quality held in Washington, D.C. on January 8-9, 1985, sponsored by the Consumer Federation of American and supported by the Environmental Protection Agency, the American Institute of Architects, and other organizations.

The AIA believes that the DOE programs described in its budget request documents need to be part of a comprehensive strategy of research. In addition DOE should place greater emphasis on research on commercial structures, work with the private sector to establish effective monitoring procedures and to create a large data base for non-residential buildings, and develop mitigation techniques and equipment.

Beyond the $900,000 that we believe could be saved from the Administration's technology transfer program, we believe that other aspects of the DOE energy conservation research budget could be reduced to permit increases in activities of higher priority.

SOLAR BUILDINGS RESEARCH

Solar energy techniques and applications can complement energy conservation activities. While the latter aims at reducing air infiltration or leakage or developing designs that result in the most efficient use, the former substitutes the limitless power of the sun for the limited resource of fossil fuels. Passive and active solar techniques can increase energy savings by 40 percent beyond what can be achieved through the application of energy conservation methods. As it supports active solar programs, the AIA has a particular interest in passive solar research activities because of their greater implications for building design. DOE's passive solar energy programs have advanced the art of passive solar design in several ways. Performance data on residential and non-residential buildings have been established. Residential design tools have been validated. Residential heating systems, preliminary residential cooling systems, and promising materials for storing heat and for glazing window systems have all been developed under the passive solar research program.

At the same time, there remains much work to be done essentially in non-residential buildings. The AIA believes that three areas of passive solar research deserve the highest priority -- aperture materials, systems integration, and technology transfer.

Aperture Materials

The AIA supports $1.45 million for the aperture materials line item, which is $900,000 more than provided for FY 1985. We place high priority on this research aspect because it will produce the materials necessary to develop new types of glazing systems and coatings for windows. This area has more potential for a major breakthrough and will provide a greater contribution for solar application than thermal energy storage research, which the Administration plans to increase.

In conducting research into aperture materials and thermal storage, DOE should give added emphasis to assembling this research in actual building components. For example, glazing materials under development should be tested in windows. DOE should also explore daylighting techniques for atriums and cores of buildings.

Systems Integration

The AIA agrees with the Administration's over-all request for $4.1 million for systems integration, but we would apply slightly more to the non-residential buildings aspect of this research. Systems integration is the solar buildings version of the whole buildings research program which examines the performance of individual building components in relation to one another and to an entire building system.

DOE is moving in the appropriate direction under systems integration with a varied program. The Department plans to address multifamily and non-residential structures, types of buildings which DOE study has neglected to date. DOE is also moving toward applying first generation heating and lighting concepts to actual building design, and plans to consider retrofit applications.

Additionally, the program will package current research findings on daylighting into design guidelines, will move into daylighting systems for more complex buildings, and will explore ways to bring daylighting into the core of buildings, which will make building interiors use less energy for lighting. About 60 percent of energy use in office and retail facilities goes for lighting. Finally, the program will verify energy performance of laboratory prototypes and analytical models through performance monitoring, and it will work on passive solar cooling systems.

Technology Transfer

This function is closely related to the technology transfer program of the Building and Community Systems program. We have recommended $900,000 for this solar program. Unfortunately the Administration prefers not to fund it at all. The AIA thinks this is a mistake because it would greatly interfere with the dissemination of information about government sponsored research.

For FY 1986, the overall passive solar program should place greater emphasis on the following: integration of building materials and components in full scale building design; establishment of a common format for collecting cost and performance data on solar buildings that is acceptable to architects, engineers, lighting designers, and the financial community; and application of passive solar techniques to other buildings types such as retail and school facilities.

Mr. Chairman, before I close I must comment on recently reported remarks of Dr. Alvin Trivelpiece, Director of DOE's Office of Energy Research. Dr. Trivelpiece is reported to have said at a Cornell University seminar on April 30, that "since economic benefits go hand-in-hand with...efficiency improvements, there is not a strong rationale for federal research and development that would improve industrial processes generally, or develop buildings or design buildings." If, in fact, this statement reflects the official current policy of DOE, we believe that it seriously misstates the relationship between energy conservation research and energy efficiency, particularly insofar as building design is concerned. Building design research leads to energy efficiency, not the other way around. With elimination of federal support and guidance for basic research into the way various building components perform in relation to one another, progress toward improving energy efficiency in design will be severely hampered, especially in light of the inability of the architectural profession and the construction industry to undertake this research on their own. Basic research into energy efficiency in buildings is a critical federal responsibility because of the manner in which it serves the nation's economic and security interests and we are deeply disappointed that apparently not all DOE officials subscribe to that idea.

Mr. Chairman that concludes my testimony. I am pleased to answer any questions you may have.

Senator **Evans**. Thank you very much.

Dr. Lawrence.

STATEMENT OF DR. LLOYD R. LAWRENCE, JR., VICE PRESIDENT, MECHANICAL TECHNOLOGY, INC.

Dr. **Lawrence**. Thank you, Mr. Chairman.

I would request that my printed version be made a matter of the record, and I will summarize briefly, if I might.

Senator **Evans**. Certainly.

Dr. **Lawrence**. Thank you, Mr. Chairman.

I'm Bob Lawrence, Vice President of Mechanical Technology, Incorporated. We are a $70 million operation involved half in products, half in research and development, and headquartered in the northern part of New York State. We are very heavily into the application of high technology to energy-conserving equipment.

One of our key programs is the Stirling engine program, which we have had with the Department of Energy since 1978. This program was actually managed by NASA/Lewis Research Center. If I can briefly restate the specific objectives of this program that come from the public law.

They are: a 30 percent improvement in fuel economy over a comparable production engine, and operation within the projected 1985 emissions standards, interchangeable operation on a variety of fuels, reliability and life expectancy comparable to commercial engines, initial costs and life cycle costs competitive with conventional engines, acceleration suitable for safety and consumer considerations, and noise and safety characteristics meeting the 1984 Federal standards.

I think you'll agree, Mr. Chairman, that those are a very stringent set of goals, and I'm happy to tell you that our program is on schedule, within budget, and meeting or exceeding its technical milestones. We have achieved already about half of those goals with the Mod 1 engine. We expect to achieve every single one of those goals with our Mod 2 that is presently now being fabricated.

Over the last several years since the inception of the program the National Aeronautics and Space Administration in the form of the NASA/Lewis Research Laboratory has rated this program every six months with an extensive evaluation, looking at all of the various aspects of the management and the technology. It is my pleasure to report that for the last three years running NASA has rated this program outstanding in every single category in each of its six month evaluations. We believe that this is a precedent-setting thing with NASA.

We are proceeding with the MOD 2 as directed by last year's continuing resolution. The engine parts are being fabricated, and we will run MOD 2 engines by the end of Fiscal year 1985 with the development and testing proceeding into 1986. The program is now destined to end in September of 1987.

Over the past few years the various subcommittees of the Congress have asked us to make every effort to increase the interest from other parties in this program, parties that are capable of commercializing this engine. And I am happy to say that with the industrial test and evaluation program that was performed this summer, that is indeed happening.

General Motors took one of our automobiles with an engine in it and gave it a month-long test sequence at their dynamometer and track facilities in Detroit. This past summer John Deere also took a Mod 1 engine and put it through a test sequence out at its production facilities.

Belmont Corporation, interestingly enough, has spent almost $4 million to date in the attempt to develop a coal-fueled Stirling engine option for irrigation pumping, and this same system would be very viable in other things like small co-generation units. FMC Corporation and Cummins Engine Company are also now involved with us in an evaluation mode on our engines.

I would like to point out that until we actually had operating engines that we can show people and they could see the test data on that indeed this involvement and interest was very small. Now that we have the Mod 1s and are proceeding with the Mod 2 and can show, in fact, the potential, the interest is growing rather substantially.

I guess the only other thing that I didn't mention was that in those test sequences both General Motors and John Deere paid for the testing themselves. It was not paid for by the Government.

In summary, the program continues to be characterized by success and exceptional progress. We have found a great many applications of the engines now, not just simply automotive applications. We have achieved a 38½ percent efficiency on our Mod 1s. We expect to be in the 40 percent with the Mod 2.

The Government also in this program will reap benefits other than just in the consumer sector in that there is a royalty payback clause in the contract where the Government will be paid back a sum of 2¼ times its total investment in this program. And when the program is completed then at the end of fiscal year 1984, the Government can expect up to $225 million in payback.

Finally, Mr. Chairman, I would like to congratulate you on your statement at the end of the Department of Energy's testimony today concerning the importance of these conservation programs across-the-board. They are indeed important. I spent about half my career in Government and the other half in the private sector, and I don't see any other program any place in Government that have as much promise of evolving revolutionary products that we can use to enhance our own economy and get back our balance of trade deficits.

Thank you very much for the opportunity to speak here today.

[The prepared statement of Dr. Lawrence follows:]

TESTIMONY ON THE DOE STIRLING ENGINE PROGRAM

Subcommittee on Energy Research and Development
Senate Energy Committee

Presented by:
Dr. Lloyd R. Lawrence, Jr.
Vice President
and
Noel P. Nightingale
Program Manager
Automotive Stirling Engine Development Program

May 14, 1985

MECHANICAL TECHNOLOGY INC.

About the Authors . . .

Dr. L. R. Lawrence, Jr.

Dr. Lawrence is Director of Technical Development for Mechanical Technology Incorporated (MTI). In this position, he is responsible for long-term corporate planning with primary emphasis on productivity, Stirling engines, Rankine cycles, heat pumps, and waste heat utilization. He is actively involved in the development of new markets for high-efficiency, high-reliability equipment. Prior to his present position, Dr. Lawrence was Director, Energy Conservation Research with the Gas Research Institute where he was responsible for the Gas Industry's program addressing the improved end-use of natural gas. He has been an executive with the Energy Research and Development Administration and with the Air Force Office of Scientific Research. In 1974, he was an Air Force Nominee for America's Ten Outstanding Young Men of the Year. He holds a number of professional memberships and has numerous technical publications.

Noel P. Nightingale

Mr. Noel Nightingale is the Program Manager of the Automotive Stirling Engine Development Program. Mr. Nightingale is employed with the Stirling Engine Systems Division of Mechanical Technology Incorporated, Latham, New York, a high-technology research, development, and manufacturing company. He has been involved in the ASE Program since its inception in 1978 and has authored various papers on its progress. Prior to that, he was employed for more than twelve years with Pratt & Whitney Aircraft, a Division of United Technologies Corporation. During that period he undertook technical and managerial roles in the design, analysis, and development of military and commercial gas turbines and large (100 MW) ground power units. He also has management experience in multinational consortium programs and aircraft maintenance. Mr. Nightingale holds a Bachelor Degree in Mechanical Engineering from the University of Toronto and Master Degrees in Engineering Science and Business Administration from Rensselaer Polytechnic Institute.

MECHANICAL TECHNOLOGY INCORPORATED
968 ALBANY-SHAKER ROAD
LATHAM, NEW YORK 12110
85M18

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before the
Senate Subcommittee on Energy Research and Development

Mr. Chairman, members of the subcommittee, my name is Bob Lawrence, and I am a vice president with Mechanical Technology Incorporated (MTI). With me today is Noel Nightingale, the program manager of the Automotive Stirling Engine (ASE) Development Program which is funded and managed by the Department of Energy (DOE). The NASA-Lewis Research Center located in Cleveland, Ohio, is responsible for the project management of the program. The program is being conducted within the Stirling Engine Systems Division (SESD) of MTI. MTI is a high-technology research, development, and manufacturing company located primarily in the state of New York, with wholly owned subsidiaries in Michigan and California. The SESD employs approximately 120 people directly in the development of Stirling engines for a variety of applications. A large number of subcontractors and consultants are also involved. This team, primarily professionals, was formed by MTI in response to the national need for an advanced energy-efficient technology, in this case, the Stirling engine. The development program requires $16 million for fiscal year 1986 to continue the Mod II effort as planned.

Mr. Chairman, MTI appreciates the opportunity to appear before this subcommittee to testify on the ASE development program. It is my pleasure to report that the ASE program continues to achieve its technical goals, while remaining on schedule and within budget. The requests made by Congress have been met and the program is on target for the development of a Mod II engine and the final demonstration of the overall program goals. Our testimony reports on the status of the two basic goals of the ASE development program:

- Develop the Stirling engine for automotive applications; and
- Transfer Stirling engine technology to the United States.

In addition, I shall comment on the results of the Industry Test and Evaluation Program (ITEP) with General Motors and John Deere, on the increased interest in Stirling engine technology by industry and the military, on foreign development activities and their possible threat to our industry base, and on proposed development activities after completion of the ASE program. I shall close with a set of conclusions and recommendations regarding Stirling engine technology. All figures or tables referenced in the text are included, for your convenience, in numerical order at the end of this testimony.

BACKGROUND

In Section 302(b) of Public Law 95-238, the United States Congress charged the DOE with initiating programs leading to the development of advanced automotive propulsion systems. DOE selected two basic engine cycles: the gas turbine and Stirling. The Stirling engine was selected because of its intrinsic capability to provide high cycle efficiency; i.e., when installed in an automobile, the Stirling engine can attain a higher fuel economy than that of conventional power systems. Further, since the engine uses a continuously burning external combustion system, it is capable of using a variety of liquid fuels while maintaining low emission levels.

MTI is the prime contractor on the program, with United Stirling of Sweden (USAB) as a subcontractor. USAB provides a strong background in Stirling engine technology, and their participation in the program has served to ensure the successful transfer of Stirling engine technology and know-how to the United States.

The logic set forth in the program was to develop two experimental engines in sequence. The first engine, the Mod I, was a new engine design, based on USAB Stirling engine technology as it existed at the beginning of the program in 1978. The second engine, the Mod II, was to be designed in the United States, and was to incorporate technology advancements made during the course of the ASE program. The program is currently in a transitional phase as emphasis has shifted from the Mod I to the Mod II engine.

The ASE program has a number of specific objectives stemming from the public law. They are:

- A 30% improvement in fuel economy over a comparable production engine

- Operation within projected 1985 emissions standards ($NO_x \leq 0.4$, HC ≤ 0.41, CO ≤ 3.4 grams/mile, and particulates ≤ 0.2 grams/mile)

- Interchangeable operation on a variety of liquid fuels

- Reliability and life expectancy comparable to commercial engines

- Initial cost and life-cycle cost competitive with conventional engines

- Acceleration suitable for safety and consumer considerations

- Noise and safety characteristics meeting the 1984 Federal Standards

Although the time frame and magnitude of the ASE program have been altered by budget restrictions over the past years, progress toward the goals and objectives has not waivered. The procurement of Mod II hardware has begun. Testing of the first Mod II engine will begin late in calendar year 1985. Fiscal year 1986 will be devoted entirely to the testing and development of Mod II engines in order to demonstrate the program objectives by the end of September 1987. Figure 1 depicts this schedule. It is requested that an authorization of 16 million dollars for fiscal year 1986 be allocated for the ASE program.

BENEFITS OF THE ASE PROGRAM

To achieve national acceptance, an automotive Stirling engine must be capable of being packaged under the hood of current vehicles. It must also be able to provide sufficient power to propel a five-passenger vehicle and still meet demanding performance criteria, such as acceleration from 0 to 60 mph in 15 seconds. The engine must be efficient over a wide range of power and speed conditions, providing high fuel economy both in the stop-and-go-environment of city driving and in the constant-speed cruising of highway driving. It must not pollute, and it must be capable of using alternative fuels. It must be inexpensive to manufacture and capable of being serviced (routine maintenance) by the general public. Finally, a Stirling vehicle must be capable of operation in both hot and cold climates while providing the passengers an environment that is comfortable in terms of temperature, humidity, noise, and vibration.

The decision by Congress to develop the Stirling engine for the automotive application, as opposed to other applications, continues to reap suitable rewards. Although the level of technology required to develop an automotive Stirling engine is very high and the goals difficult to achieve, the ultimate benefits will be in proportion to the difficulty of achieving these goals. Moreover, once the ASE goals are achieved, there are almost immediate windfall benefits to other Stirling applications. Examples include generator sets, irrigation pumps, solar electric, heat pumps, industrial prime movers, marine, submarine, and farm equipment. This assessment, although subjective, underscores a key national benefit - that the ASE program will provide the United States with a core technology that has a host of spin-off applications. This, in turn, will provide our nation with the additional capabilities of not only conserving energy in other crucial applications but also of maintaining the technological leadership in those areas. The benefit is already beginning to be realized, since the Army, Navy and Air Force have shown interest in using Stirling engines for military generator sets, submarines and utility vans, respectively. Commercial interest in using Stirling engines for irrigation purposes has also been expressed.

The introduction of Stirling technology into the U.S. implies a vast potential for new jobs related to new products, their manufacture and service, as well as an increase in associated trade employment. The multifuel capability of the Stirling engine will provide personal and national security in times of petroleum dislocation. The Stirling engine will meet the emission standards defined in the Clean Air Act, thereby contributing to the national effort to upgrade our environment. The ASE also provides an advantage to improving our noise environment, as the noise level emitted from a Stirling engine is much lower than that of conventional engines... a Stirling engine requires neither a catalytic converter nor a muffler. Finally, the overall potential for conserving valuable fuel resources through the use of more efficient Stirling engines in automobiles and in other applications is immense.

1984 ACCOMPLISHMENTS

Progress during 1984 was made in three major areas. The Mod II engine design and technologies were further refined and developed. An important test and evaluation program of the Mod I Stirling engine was conducted by General Motors Research Laboratory and John Deere; and, finally, Mod I engines continued to test successfully, yielding valuable durability and reliability information. A more descriptive summary of each area is provided in the following paragraphs.

Mod II Engine

The Mod II engine was designed to meet the program objectives of providing a highly efficient power plant with a competitive manufacturing cost. During the past year, an independent study was made of the manufacturing cost of the Mod II. The study was conducted by Pioneer Engineering and Manufacturing Company of Detroit, Michigan, a highly respected company in the automotive industry. Their report contained a detailed cost breakdown for the basic engine, auxiliaries and vehicle integration components. A life-cycle cost analysis, which compared the Stirling engine to spark ignition and diesel engines, was also included. Their overall conclusion was that the Mod II was cost competitive with spark ignition and diesel engines. This factor, coupled with the lower weight and higher efficiency of the Mod II, makes the engine a viable alternative power plant to existing systems.

To emphasize the impressive reduction in size and, therefore, weight and cost in the Mod II, Figure 2 compares the engine cross section of the Mod II to that of the Mod I. Figures 3 and 4 depict the reductions made in the specific weight and manufacturing cost, respectively, of the Mod II to make it competitive with existing power plants.

Two of the major parts in the Mod II that contribute to its lower cost are the single-piece vee-block casting and the annular heater head casting. These parts are identified in the cross section in Figure 2. During the past year, each of these components has been manufactured and developed using United States vendors. The single-piece vee-block was cast by a Wisconsin vendor. A photograph of a machined casting is provided in Figure 5. Plans are now being carried out to develop castings at a modern manufacturing facility at John Deere. The machining of the castings at John Deere is also being planned. The annular heater head, a photograph of which is shown in Figure 6, was cast by a company in Indiana. Mod II components have been under development throughout 1984 and have now been designed to their final configuration for the Mod II engines.

The manufacture of Stirling engine hardware under the ASE program has required the support of a host of companies throughout the U.S. Although the cost to produce the limited number of prototype parts needed in the program is quite high, there are three important compensating side effects. First, the vendors have developed the skills and understanding necessary for the proper manufacture of Stirling engines. Second, the critical tooling, which in some cases exceeded a cost of $100,000, is in place, which means that there would be no lengthy delays for the procurement of additional hardware. Third, the need for the hardware has had a positive impact on the labor force. Table 1 illustrates the magnitude of the vendor base already established in the U.S. to manufacture Stirling engine hardware.

Industry Test and Evaluation Program

Due to the foresight of this and other Congressional subcommittees, the Industry Test and Evaluation Program (ITEP) was initiated in fiscal year 1983. The ITEP was directed at providing two engines for industry to test, evaluate and assess the applicability of Stirling engines. General Motors, John Deere Company and the Cummins Engine Company all signed formal agreements with NASA/Lewis to participate. The first engine packaged in an AMC Spirit was delivered to General Motors Research Laboratories (GMRL) in April 1984. A photograph of the vehicle is shown in Figure 7. General Motors tested the vehicle on the road; in a wind tunnel, with temperatures as high as 125°F; and on a chassis dynamometer, according to the EPA Urban and Highway procedures. More than 1,082 miles were logged on the vehicle during these tests. A second engine was prepared and shipped to John Deere in August 1984, where it was evaluated in a test cell. Cummins' role in the ITEP was to keep abreast of the test results obtained at each test site.

In both cases, the engines proved to be reliable and experienced no failures. A summary issued by GM of the test results stated that "the reliability of the Stirling engine system was remarkable during the 54.7 hours of testing."

Prior to the GM test program, an AMC Spirit vehicle equipped with a spark ignition engine was tested according to EPA procedures, yielding a combined mileage of 22.5 mpg. The spark ignition engine was then removed from the Spirit, and the first ITEP Mod I Stirling engine was installed in the same vehicle. When tested, the Mod I yielded a combined mileage of 25.5 mpg which is a 13% improvement; however, acceleration times were not the same for both engines. The Spirit vehicle with the spark ignition engine required 18 seconds to accelerate from stop to 60 miles per hour, whereas the Mod I equipped Spirit required 26 seconds. These results indicated that the Mod I engine was underpowered for the 3,250-lb Spirit vehicle. It was General Motors' judgment that the power level of the Mod I more closely matched the power level of a lighter vehicle, such as their 2,500-lb Chevette vehicle. At this test weight, the Mod I Spirit vehicle required basically the same time to accelerate from stop to 60 miles per hour as the Chevette equipped with either a spark ignition engine or a Mod I engine.

Figure 8 is a combined mileage curve for the United States vehicle fleet average for various vehicle weights. This curve, provided by GMRL in their report submitted under the ITEP, points up the well-known fact that lighter vehicles provide higher mileage. Of particular interest on this curve is the mileage of the Mod I Spirit measured by General Motors at test weights of 3,250 lb and 2,500 lb, with the acceleration time between stop and 60 mph shown in brackets. When compared to the GM Chevette (at 2,500 lb), the mileage of the Mod I Spirit was 15% lower. The General Motors test results indicated that the idle fuel flow was too high and engine powertrain matching characteristics were not optimum. Since the General Motors tests, important changes in these two areas were made to the Mod I Spirit in response to the GM evaluation. The Spirit was retested and yielded higher mileage and better acceleration time. It should be noted that all of these changes are technologies designed into the Mod II engine and vehicle system.

The results of these improvements are reflected on Figure 8. The mileage at 2,500 lb increased to 31 mpg, a level almost equal to the Chevette and the U.S. fleet average. However, acceleration improved to 13 seconds, making a comparison at 2,500 lb inappropriate. A comparison at 3,250 lb is appropriate since the acceleration at that weight was 17 seconds, which is comparable to the original spark ignition Spirit and the U.S. fleet average. The mileage at 3,250 lb is 30 mpg, which is 18% above the fleet average. The purpose for this comparison is to underscore the valuable contribution GM made in evaluating the Mod I Stirling Spirit. GM supported the tenet that fuel economy figures can be compared only after first matching acceleration times. Moreover, GM provided a technical critique which was understood and accepted by our engineering staff. In response, we incorporated improvements in the areas pointed out by GM, and the Spirit mileage and acceleration time improved to the point where the Stirling is above the U.S. fleet average at 3,250 lb with comparable acceleration. This type of industry input is extremely valuable to the success of the ASE program and will be pursued.

GM also included in Figure 8 mileage figures for other alternative powerplants of the past - 1976 steam (SES), 1977 Stirling (Ford) and 1978 gas turbine (Chrysler). For comparison purposes, the Mod II fuel economy has been added to this figure. The Mod II is projected to have an acceleration time of 13 seconds and a combined mileage of over 40 mpg when installed in a GM Celebrity vehicle in the 3,125 inertia weight class. The Mod II fuel economy will be 50% above the U.S. fleet average. The growth path pursued by the ASE program is shaded over the figure to emphasize the advancement made in Stirling technology. It is worth noting that the progress made in the state of technology since 1977 points to a crossover that has occurred between the U.S. fleet average and Stirling technology. Demonstration of the Mod II fuel economy will, in fact, show the superiority of the Stirling engine in the automotive application as compared to conventional technologies reflected in the U.S. fleet average curve.

Stirling Engine Reliability (Mod I)

During the past year, seven Mod I engines have undergone active development testing, bringing the total accumulated test hours to 8,681 by the end of

1984. Figure 9 shows the number of test hours accumulated each year. If industry is expected to accept Stirling engine technology for their product lines, they must be convinced of the engine's reliability through test hours. Warranty claims and maintenance costs are prohibitively high when a product is found to be unreliable. This point represents one of the arguments for keeping Mod I engines under active test in the ASE program, that is, for the sake of industry involvement.

In spite of the attractive performance expected from the Mod II, performance is only one of many issues addressed by industry. Reliability and durability are of equal importance. Funding levels allow the manufacture of only three Mod II engines between now and the end of the program in September 1987. It is anticipated that no more than 1500 hours will be accumulated on these engines during the time frame of the program which is insufficient for industry acceptance. It behooves us to continue to support and test the Mod I engines built under this program to demonstrate the reliability and durability of the Stirling to industry.

INDUSTRY AND MILITARY INTERESTS WITHIN THE UNITED STATES

Mr. Chairman, during the course of this program, we have gained notice and respect from the automotive companies in the United States. Their reaction has changed from negative to positive interest - yet without commitment. This is understandable and should not be construed in a negative sense. It is an expected reaction. It is an extremely difficult task to commercialize an innovative engine in the automotive marketplace. The American public is accustomed to highly dependable and reliable vehicles and is unwilling to put up with the vagaries of a new engine concept.

Over the past twenty years we have seen Chrysler attempt to introduce turbine-driven cars; Ford, Proco engine-driven cars; and General Motors, rotary Wankel, multi-cylinder 8-6-4 engine and diesel-driven cars. In all cases, early operational uncertainties drove these options from the marketplace. As a result, we see more and more American automotive companies purchasing new engine options overseas after they have been tested and proven in foreign markets supported by foreign government research and development funds, rather than attempt a new concept in the U.S. marketplace. Therefore, in spite of the success of the Stirling, the reason the automotive industry is reluctant to enter into a new engine technology like the Stirling is readily apparent. The ASE program has not yet demonstrated the 30% fuel economy goal, nor has it presented an engine in hardware form that can be manufactured at a competitive cost. Until these goals are demonstrated, it is unlikely that industry will become actively involved. The Mod II is directed at achieving this milestone.

During the past year there has been a steady increase in interest by non-automotive organizations. One company, Valmont, located in Nebraska, is the leading U.S. manufacturer of mechanized irrigation systems. Although they have invested more than $4 million in Stirling engine development, the technology level demonstrated in the ASE program has prompted their interest in the Mod II for a product. The annual consumption of resources for irrigation systems is over 257 trillion Btu, over 2 billion gallons of diesel fuel, 118 billion cubic feet of natural gas and 21 billion kilowatt-hours of electricity. Pumping costs per gross crop value rose from 3% in 1973 to 18% in 1980.

Therefore, fuel efficiency represents a sizeable advantage to the economics of a portion of the farming community. By using inexpensive coal, burned in a fluidized bed, a Stirling engine can be operated through the energy transferred by a heat pipe. The Stirling engine, in turn, would pump the water from the ground and propel the irrigation system to pass over the crops. A schematic of this application is shown in Figure 10. It is projected that a Stirling engine system would be considerably more efficient than existing systems and it would make use of a less expensive resource - coal. It is estimated that more than $750 million per year in irrigation costs could be saved in this industry that has over 80,000 mechanized systems and 509,500 pumping plants that irrigate over 61 million acres.

The military has also begun to show interest in the many positive features of the Stirling engine. The Army, for example, has active programs underway using Stirling engines as the power source for 3-kW and 5-kW generator sets. They have recently shown an interest in evaluating a Mod I engine from the ASE program in a 30-kW generator set. The use of the Mod I engine will provide a demonstration of the potential gains to be made in using a Stirling engine prior to the availability of the Mod II. The Mod II, of course, is the preferred engine, since it has the more attractive manufacturing cost as well as higher performance.

The Army is interested in the Stirling engine because it can use diesel fuel, yet run quietly, with accompanying low emissions and high efficiency. The Air Force, on the other hand, is interested in using a Mod I engine to demonstrate its advantages for use in a service van. Air Force vans spend a great deal of time at idle while maintenance crews service aircraft on the tarmac. The attractiveness of the Stirling is that it can use JP-4 fuel; therefore, it offers the Air Force a van that uses the same fuel as their aircraft. Again, the long-term goal would be to use the Mod II because of its lower manufacturing cost, fewer parts to reduce maintenance costs and higher efficiency, particularly at idle.

The Navy is interested in the use of the Stirling for submersible units. The main attractiveness is the low noise level. Although the Mod I engine is quiet, it exhibits gear noise because of its two crankshafts that are geared to a single output shaft. The Mod II, on the other hand, is a vee-engine with only one shaft, and it is projected to have lower noise levels than the Mod I or any other nonmuffled engine.

The interest shown by the military is, indeed, encouraging and provides an incentive for continuing the Mod II program. Interest is expected to increase as the technology is better understood throughout the armed forces. It should be noted that all three activities were initiated within the past fifteen months.

STIRLING ENGINE DEVELOPMENT PROJECT IN JAPAN

Nearly 70% of the primary energy requirements in Japan rely on imported petroleum. Although the supply and demand for oil is currently stable, the long-range scenario for a stable supply is doubtful. The development of new nonpetroleum engines and the technical development of energy-conserving equipment has been recognized as necessary. A large-scale Japanese research and development project entitled "Stirling Engines for Wide Use" was set up and started in 1982. This was part of an energy conservation program named "Moon Light Project" at Japan's Agency of Industrial Science and Technology (AIST), Ministry of International and Trade Industry (MITI). Total funding is nearly 10 billion yen (43.5 million U.S. dollars) for the six-year Stirling engine development effort slated through fiscal year 1987.

The Stirling engine project objective is to realize 3-kW and 30-kW class engines with better fuel economy, fewer pollutants, lower noise emissions and multifuel capability. The engine test demonstrations are to be made in fiscal year 1987 for use in power plants of heat pump systems to heat and air condition both residential and commercial buildings and electric power generation.

Four types of candidate Stirling engines are presently under development. A 30-kW swash-plate engine for a commercial heat pump system, designated NS30A, is being developed at AISIN SEIKI Company, Ltd., one of the project contractors. A four-cylinder, 30-kW, crank-drive engine, designated NS30S, is being developed jointly at Tokyo Sanyo Electric Corporation and Tokyo Sanyo Electric Tokki Company Ltd. for use in a compact electric generator unit. Both these engine types use technologies similar to those developed in the ASE program, such as seals, heat exchangers, combustors, drive system and control systems. Two other engine systems at a power level of 3 kW are being developed for use in residential heat pump systems. Designated NS03T and NS03M, these engine types are being developed by Tokyo Shibanra Electric Corporation and Mitsubishi Electric Corporation, respectively.

Figure 11 shows the project organization and the research and development approach of the Japanese program under AIST. Although the four Stirling engine types cited above are intended for three specific applications, it is evident that the New Energy Development Organization (NEDO) is evaluating other applications. Figure 12 is a copy of a brochure released by NEDO showing the applications contemplated for Stirling technology. It is interesting to note that the automotive application is included and strategically placed on the chart. It has been learned that a Stirling engine will be installed in a Toyota vehicle as one of the contractor special accounts within NEDO.

STIRLING ENGINE DEVELOPMENTS IN CHINA

China covers a vast land and is rich in energy resources. Since the founding of the People's Republic of China (PRC) in 1949, the energy industry in China has grown rapidly. Although annual consumption of coal is over 600 million tons, the known deposits of coal are sufficient to last for hundreds of years. In parts of China the consumption of petroleum products is escalating, while in vast areas of the country national utility electrical grids are unavailable. The transportation of fuels for wide distribution is difficult. The goal in China, then, is to utilize the available fuels locally without the need for large-scale capital investment, which creates an opportunity for the use of Stirling engines.

There are approximately six million methane wells in China, and the number is expected to increase in the near future. Straw, together with animal and vegetable waste, is used to generate methane gas. The Stirling engine offers the advantage of burning this low-Btu methane gas to generate electricity for use in these small rural communities. The goal is to provide electricity for cooking and heating to the more than 800 million people living in rural China, so that they do not have to burn straw or methane gas directly. Since many coal mines exist within the large rural area, the operation of Stirling engines on coal is also under consideration.

A Stirling engine development program was launched in 1980 at Shanghai Marine Diesel Engine Research Institute (SMDERI) to design and develop Stirling engines. A Stirling engine product development program for a 20-kW generator set was initiated by a United States company, the result of which is licensed to SMDERI in China. This company, in turn, contracted MTI to design and furnish the engine. The objective is for SMDERI to begin production of engines in China within five years. Other applications under review for this engine include houseboat transportation, coal-fired locomotive and marine applications, and solar electric power generators.

It should be emphasized that this technology has been licensed to SMDERI solely for use within China. All rights to the engine for the rest of the world reside in the U.S. with MTI. Therefore, the resulting product can be manufactured in the U.S. for sale and distribution by MTI alone, or in partnership with other American companies. This represents a significant product opportunity for the U.S.

POST MOD II

Following the completion of the ASE program, the Mod II will have demonstrated the potential to meet the exacting requirements of the automotive application. However, before any new product is ready for production there are many preproduction phases to pass through. Any preproduction phase would require that industry take the leading role. Manufacturing cost reduction programs would certainly have to be initiated, but these could not be conducted without current knowledge of the technology. Therefore, a period of technology transfer would be necessary. Reliability tests would also be required, which would call for the manufacture of many Mod II engines to be assembled and tested according to various criteria used in the industry to establish reliability and confidence in a product's durability.

The ASE program, proper, should continue to address several major areas. There will be a need to transfer Stirling engine technology to industry which is a multifaceted task. Designers and analysts must be schooled in the characteristics of the Stirling engine. The types of analysis and codes necessary to execute a design would have to be shared. The techniques in assembling and testing the engines would have to be learned. Of more importance, the characteristics of the engine would have to be taught to enable technicians and mechanics to diagnose problems.

Any follow-on to the ASE program should include additional development in the use of alternative fuels. Although the Stirling engine is a multifuel engine, the subtle changes necessary in the hardware have not been totally assessed.

The Mod II offers the potential for using ceramic materials to a larger degree than called for in its current design. After the development of the initial Mod II, this potential should be pursued more vigorously. There are efficiency gains to be made if ceramics are to be used in critical areas of the engine. As yet, the materials and the design sophistication are not available.

And finally, the Stirling engine, if it is ever to be fully accepted by industry, must be studied in light of all the possible power sizes necessary for many product lines. The automotive application is a very broad field, indeed, and the ASE program engine demonstration is only one point in a vast array of power and application mixes. It would be necessary, after Mod II, to study and design families of engines in coordination with industry to apply the design concepts and technology of the ASE program to the industry product mix.

CONCLUSIONS

Mr. Chairman, I would like to summarize with the following conclusions:

1. The Mod II Stirling engine can meet the original goals of Title III of Public Law 95-238.

2. The Industry Test and Evaluation Program, initiated and supported by this subcommittee, was highly successful and well managed by NASA-Lewis. The ITEP program underscored the technical advances made in Stirling technology over the course of the ASE program. The Mod I engine which was not designed for an automobile in particular, but rather to develop Stirling technology, compared favorably with the U.S. vehicle fleet average when installed in an automobile.

3. The demonstration of Stirling engine technology is not the only criterion used by industry to evaluate whether or not to become "involved." Manufacturing costs and reliability are two additional criteria that are viewed equally as important, or perhaps more important, than a technology that proves high performance.

4. The ASE program continues on schedule, while meeting critical technical goals requested and funded by this subcommittee.

5. Stirling engine technology provides a technological base from which the United States can maintain leadership in domestic and foreign automotive markets, as well as in markets evolving from numerous spin-off applications. The attention and support given by foreign governments and industries to Stirling engine technology threaten the economic leadership of the U.S.

6. There are many possible applications for Stirling engine technology in the military, as evidenced by the interest already shown by the Army, Navy and Air Force. Reasons cited for this interest include low noise, multifuel capability, low emissions, high efficiency, potential for long life and potential for reduced maintenance costs.

7. Stirling engine technology has been successfully transferred to the United States. As a result, a dedicated team of professionals is in the process of translating this knowledge into programs; for example, the China product, military applications, and the irrigation application. Without the continuation of the Mod II engine development and the support of the U.S. Government, the success of these first-step spin-off programs would be compromised.

8. In addition to the benefits which the United States will receive from the commercial introduction of this technology, there will be a direct financial benefit, as well. The contract requires a royalty repayment to the government of an amount up to 2-1/4 times the total value of the contract. Therefore, the government stands to gain as much as $225 million directly from the success of this program.

RECOMMENDATIONS

With the foregoing conclusions in mind, Mr. Chairman, I would like to recommend that:

1. The ASE program be authorized to continue through to the completion of the Mod II engine development. The numerous advances realized to date and those yet to be realized will be lost unless the Federal Government is willing to provide continued support to the program.

2. The Industry Test and Evaluation Program (ITEP) be continued to include additional tests at the sites of automotive companies with automobiles from their product line. If continued, the ITEP should allow for individual companies to conduct independent manufacturing cost studies of the Mod II engine.

Thank you, Mr. Chairman, for this opportunity to appear before this important subcommittee. I would be pleased to answer any questions at this time.

TABLE 1

VENDORS MANUFACTURING STIRLING ENGINE HARDWARE

- ALABAMA
  - Speed Ring

- CALIFORNIA
  - Bourns Instruments
  - Coulter Steel & Forge Co.
  - Bell & Howell
  - Kyowa Metriseal

- COLORADO
  - Coors Ceramics

- CONNECTICUT
  - Projects Inc.
  - Twin Manufacturing Inc.
  - Buckland Manufacturing Inc.
  - Omega Engineering
  - Reno Machine Company

- DELAWARE
  - DuPont

- FLORIDA
  - Air Fax
  - Speed Ring
  - Airport Metals

- ILLINOIS
  - Minority Enterprises Ltd.
  - Field Tool Supply
  - Simrit

- INDIANA
  - Howmet

- IOWA
  - John Deere

- KENTUCKY
  - Dover Corp.

- MASSACHUSETTS
  - Intronics Inc.
  - Honeywell
  - International Beam Welding
  - Lee Company
  - Landergren
  - Valley Gage
  - Poly Plating

- MICHIGAN
  - Kellogg Manufacturing
  - Wall Colmonoy

- NEW HAMPSHIRE
  - Lewis & Saunders
  - Gloenco-Newport

- NEW JERSEY
  - Valcor Engineering
  - C.B. Kaupp

- NEW YORK
  - MacLaw Tool & Aircraft
  - Steel Treaters
  - Crucible Specialty Metals
  - Atlas Mill Sales
  - MOOG

- OHIO
  - Babcock & Wilcox
  - Wall Colmonoy

- PENNSYLVANIA
  - Superior Tube
  - I.N.A. Bearing

- RHODE ISLAND
  - Tubodyne
  - Dixon

- WISCONSIN
  - Motor Castings
  - Wrico Stamping

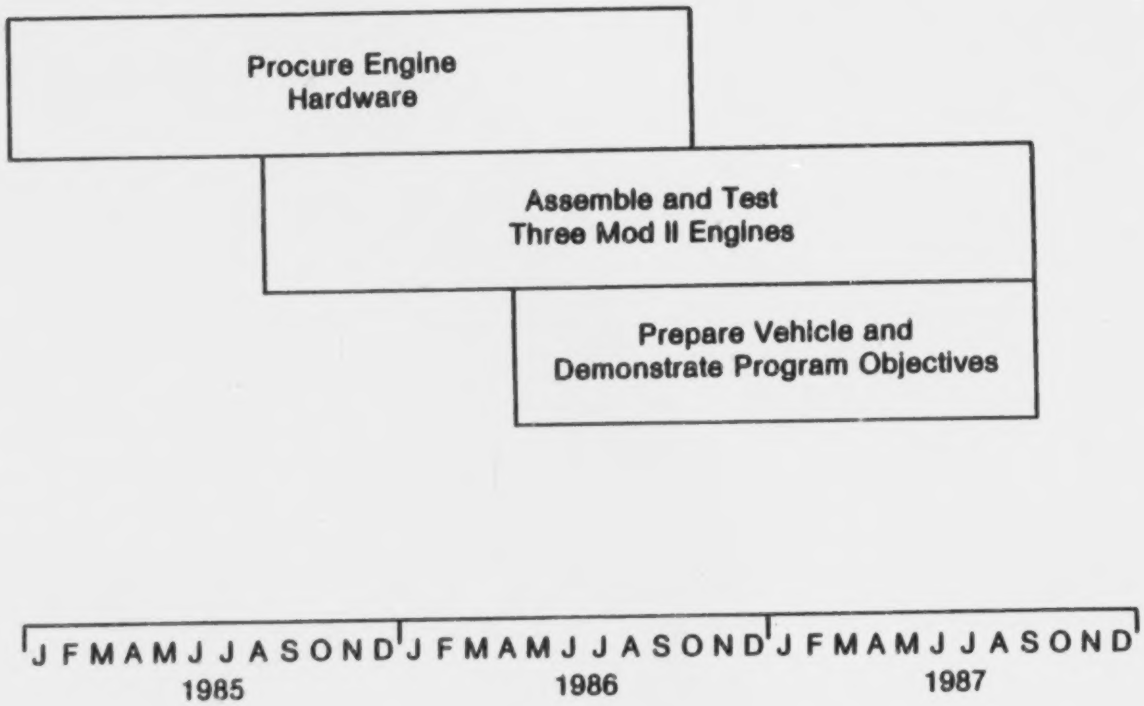

Figure 1 ASE Program Schedule: Mod II Engine Development

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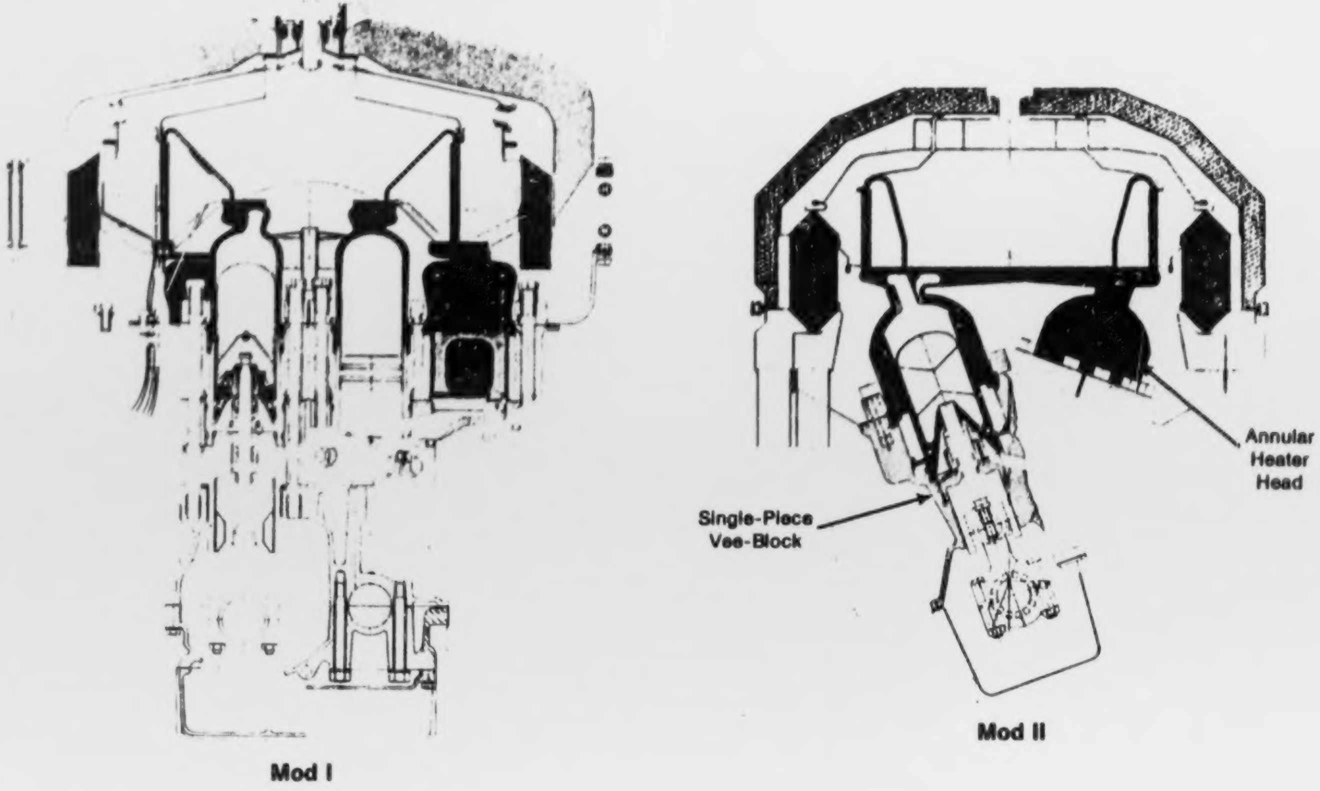

Mod I

Mod II

Figure 2 Comparison of Mod I and Mod II Engine Cross Sections

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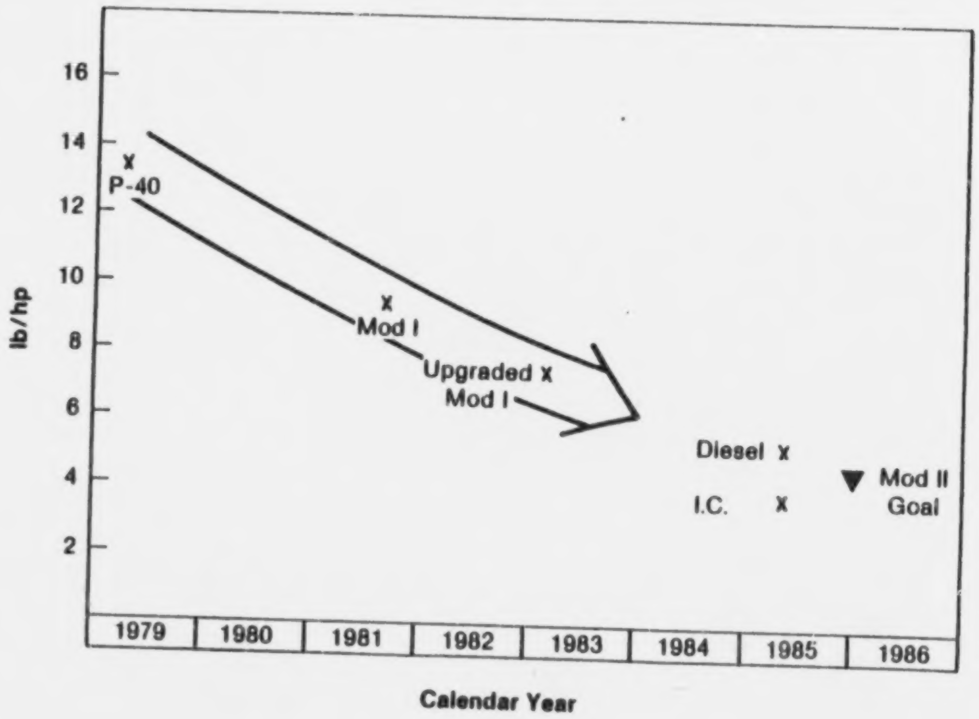

Figure 3 Reduction in Specific Weight of Mod II Engine

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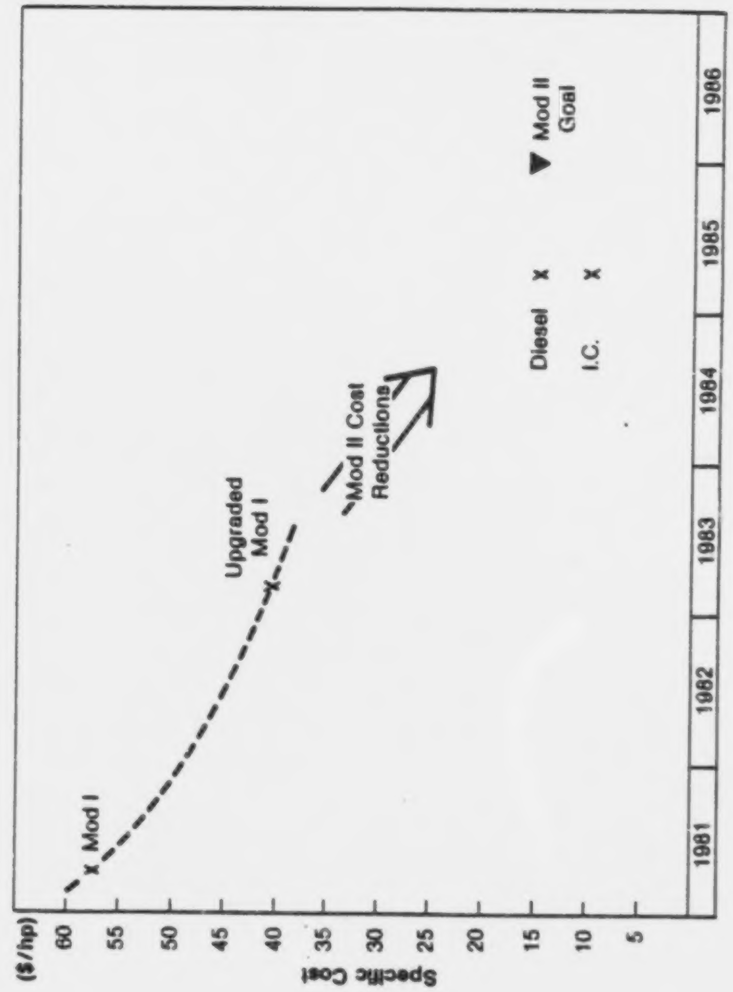

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Figure 4 Cost Reduction of Mod II Engine

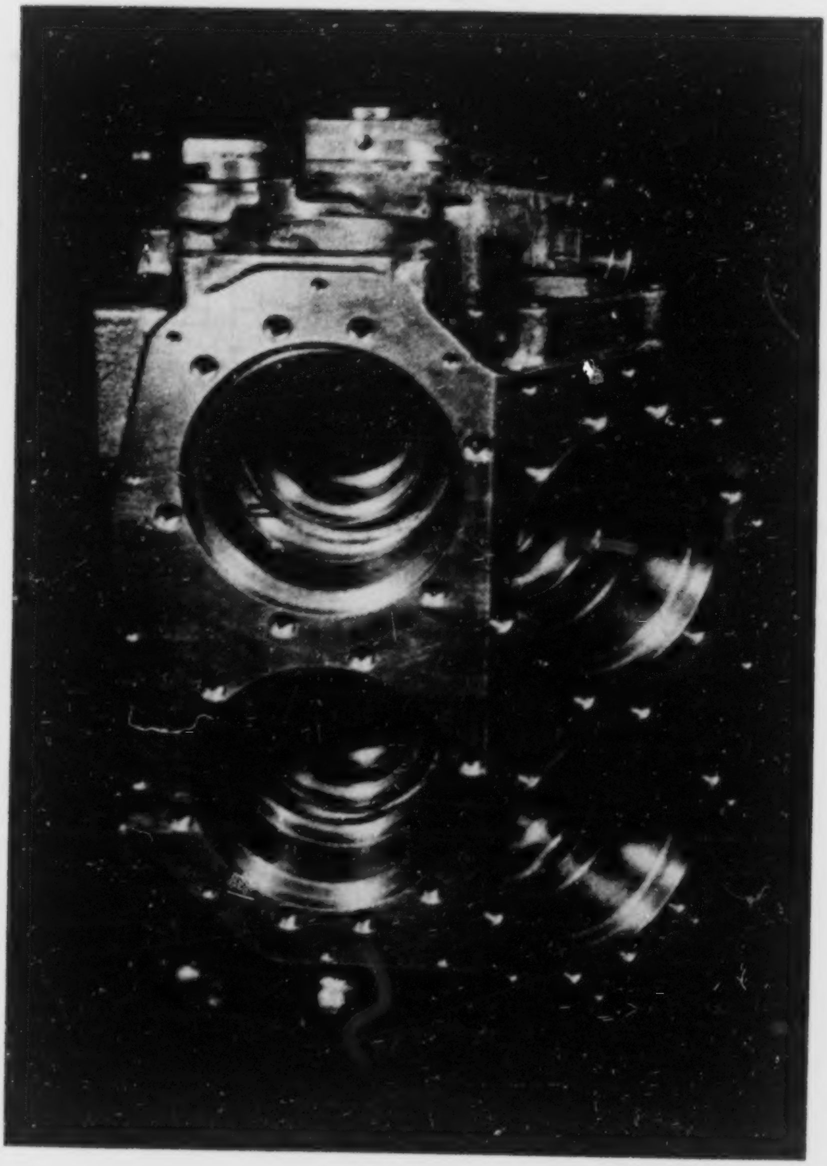

Figure 5 Single-Piece Engine Vee-Block

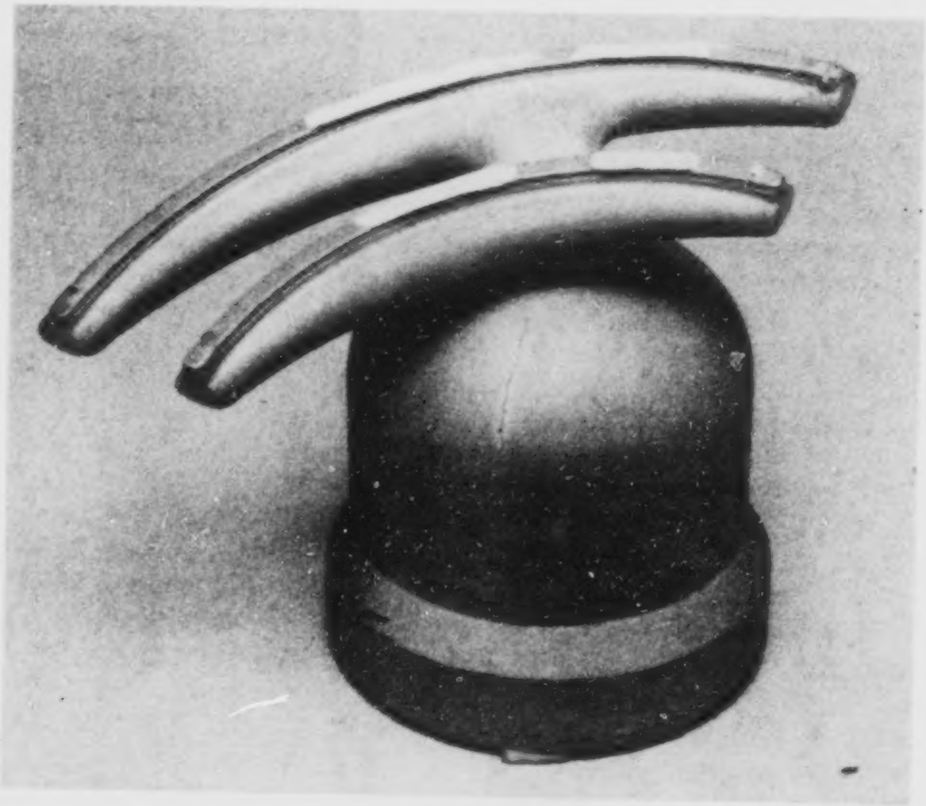

Figure 6 Annular Heater Head Casting

Figure 7 Stirling-Engine-Powered AMC Spirit

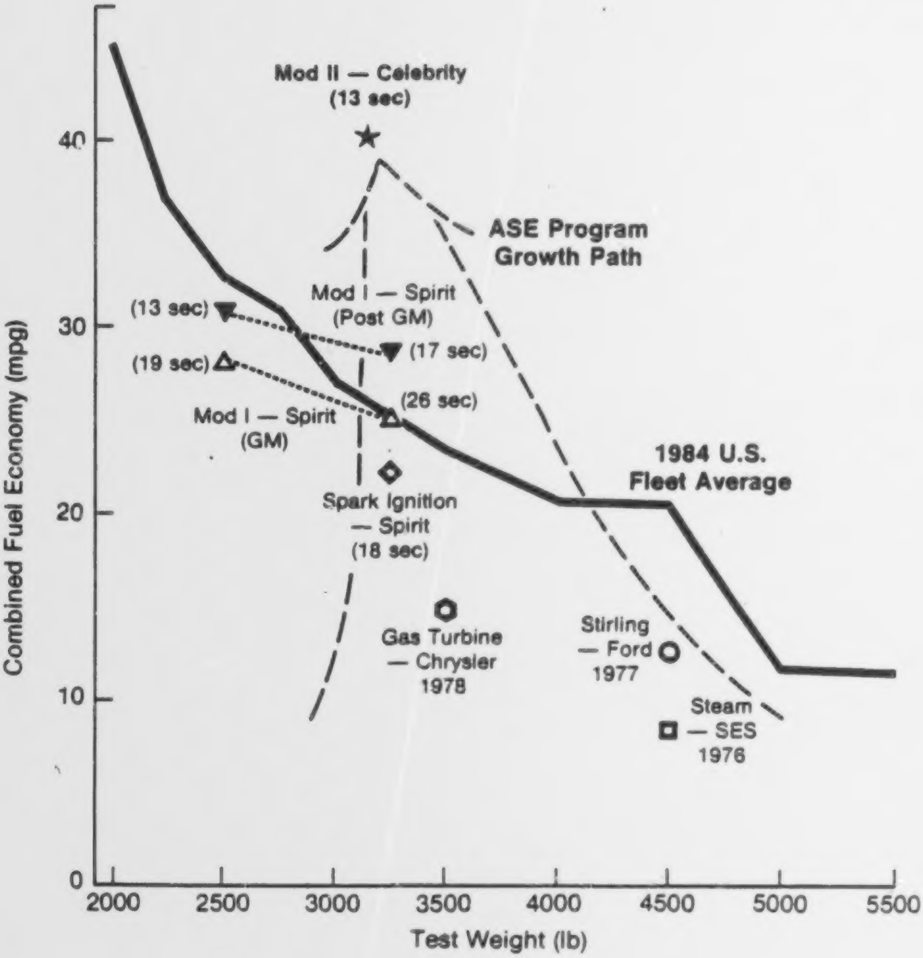

Figure 8 Stirling Engine Fuel Economy Comparison

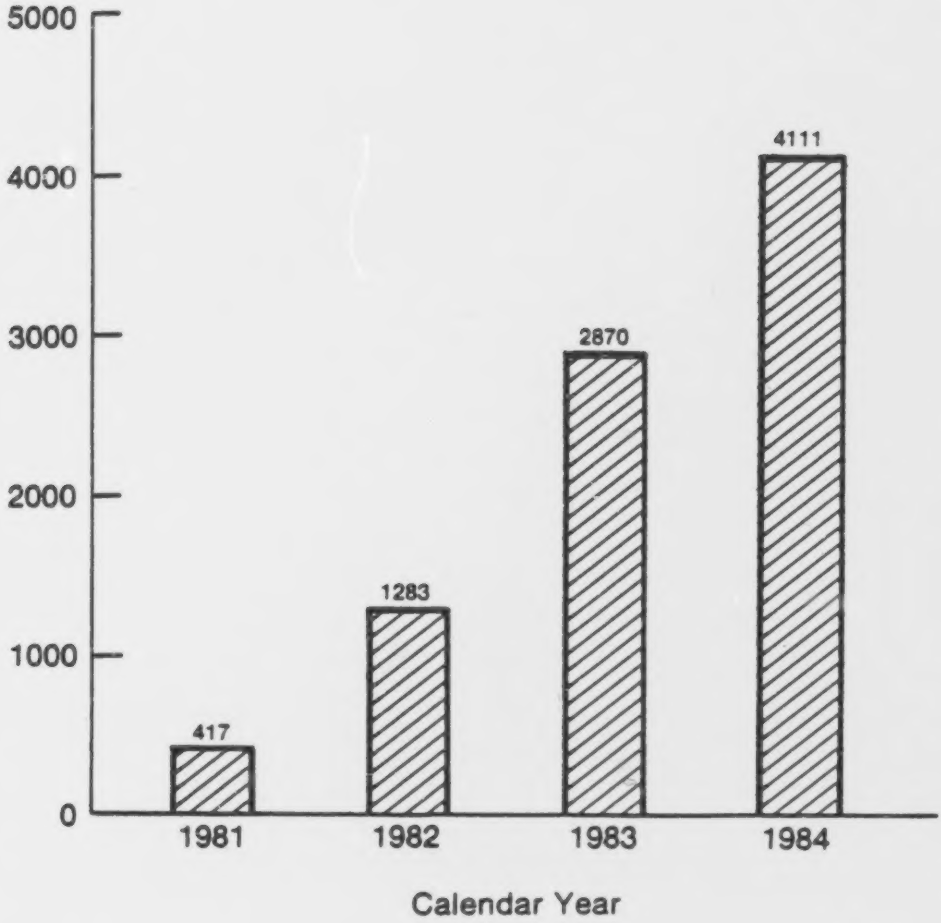

Figure 9 Mod I Engine Test Hours

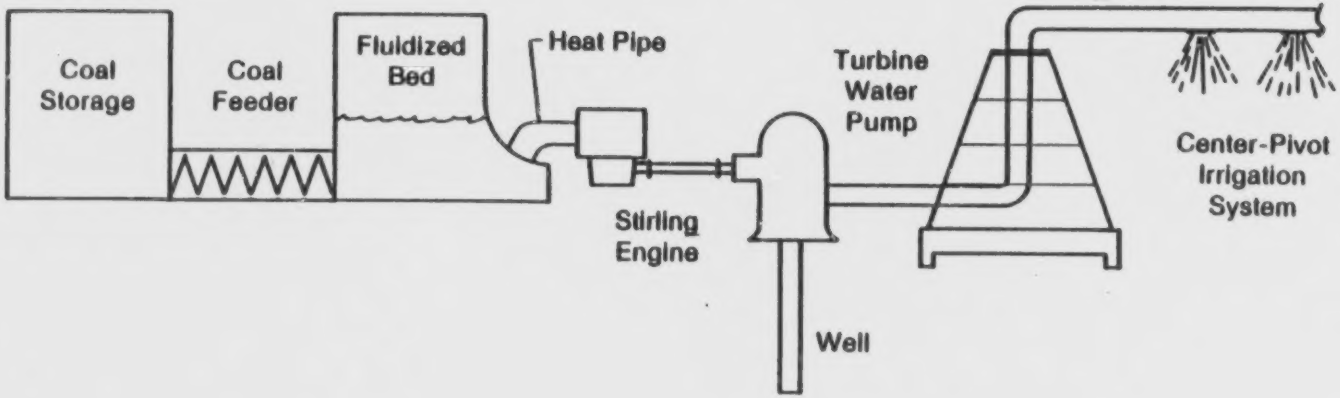

Figure 10 Coal-Fired Stirling Engine Irrigation System

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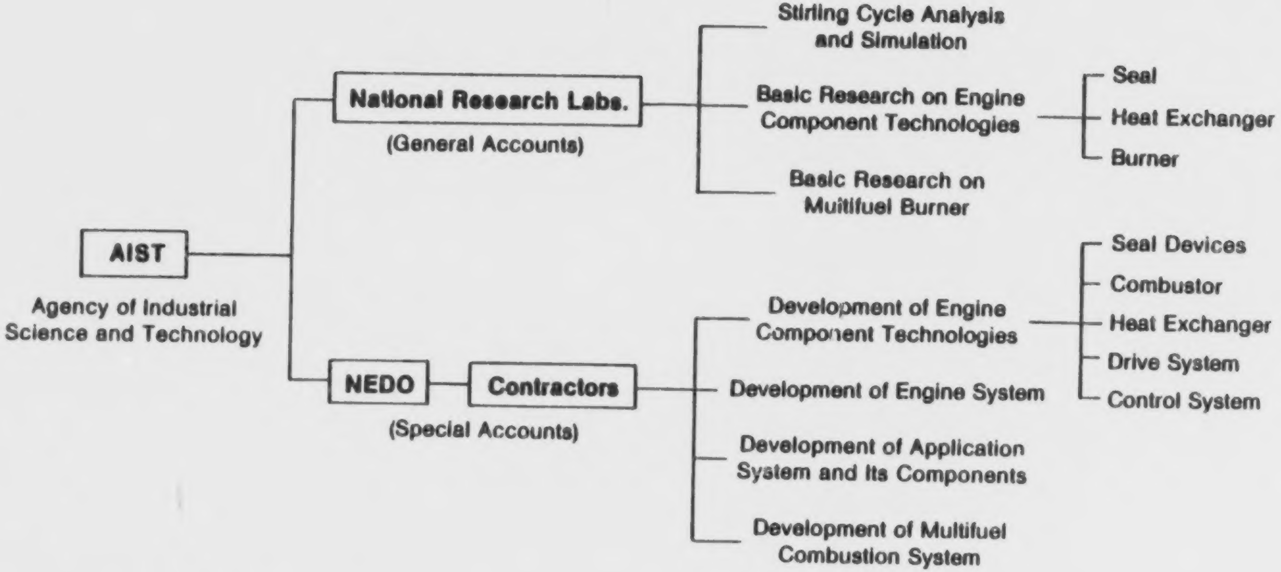
AIST
Agency of Industrial Science and Technology
National Research Labs.
(General Accounts)
NEDO
Contractors
(Special Accounts)
Stirling Cycle Analysis and Simulation
Basic Research on Engine Component Technologies
Basic Research on Multifuel Burner
Seal
Heat Exchanger
Burner
Development of Engine Component Technologies
Development of Engine System
Development of Application System and Its Components
Development of Multifuel Combustion System
Seal Devices
Combustor
Heat Exchanger
Drive System
Control System

Figure 11 Japan's AIST Project Organization and R&D Approach

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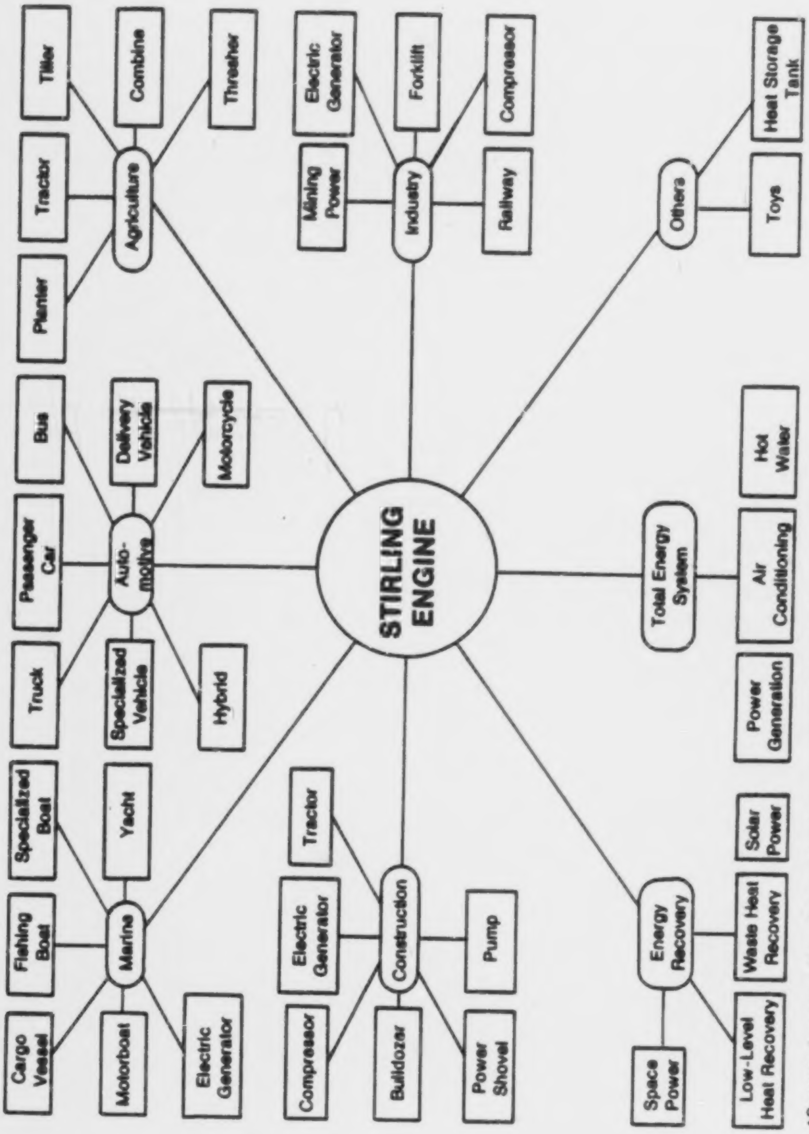

*Source: Japanese New Energy Development Organization (NEDO) Brochure, 1984

Figure 12 Japanese Stirling Engine Applications

Senator EVANS. Thank you.

Mr. Franta, I thought I heard you mention that the technology transfer—well, you say in your statement the administration prefers not to fund the technology transfer at all. Is that really accurate, or are they combining it with another program?

Mr. FRANTA. It's my understanding that the solar program technology transfer is not being funded; that other technology transfer is, but that the solar program is not.

Senator EVANS. OK. We'll check into that.

You mentioned, among other things, the desire to continue on aperture materials, that sort of research. Do you think we still need a lot of research, or are we at the point where it's really up to the manufacturers competitively to design better and more efficient, and as a result, more marketable types of aperture controls?

Mr. FRANTA. Well, I guess we've come a long way in the last 10 years, and a lot of it's been through Federal support of research in various materials areas. It seems like windows are often the bad guys in energy usage in buildings and that we still have some great steps to take in terms of getting more efficient windows. And I think the Government in the past has typically helped spark that and get things to the point where private industry has really been able to spin off and do a good job of development.

Senator EVANS. You don't feel sufficient work has been done to this date, that everybody is looking at the other elements of the building and ignoring windows? Are they behind? I'm curious as to the concentration, your suggestion that we concentrate on apertures.

I know that that's a place where a lot of energy is lost, but are you suggesting that we're not doing as much work on that as other elements of the building? It would seem to me that that would be the place to start, that that's where the most research should be done because that's where the most energy is lost.

Mr. FRANTA. Well, I think we have been doing research in that area, and we would recommend that we continue that, and that would be a high priority from an architectural or practitioner's viewpoint.

Senator EVANS. Well, that's why I'm asking the question. How long do we keep doing it? When do we get to the point where it's something that private industry, or for that matter the architectural profession and the engineering profession—that's part of what makes one firm better than another, those who have the better ideas.

Mr. FRANTA. True, and I guess—I think we're to the point that we don't need to fund that particular effort much longer, but there are still areas that are kind of right around the corner in terms of high performing windows that we would like to see get far enough for private industry to take over. I'm not sure how long that effort would take.

Senator EVANS. Dr. Lawrence, I remember with interest your appearance here last year. Would you care to characterize just what's—and I guess that was almost a year ago, wasn't it, or perhaps a little less than a year ago?

Dr. LAWRENCE. Yes, sir, I think our testimony at that time, we were about ready to move into the testing of the Mod 1 with industry, and industry really had not had a chance to interact with these engines before. I think that the General Motors test sequence this summer was really a major milestone in the program, because for the first time people can see that Stirling engines were not just a laboratory toy, but in fact they were coming to the point of being a viable power plant that could be looked at as an option for a variety of uses.

In the General Motors test sequence I would also point out that we showed that the car had very acceptable acceleration and performance and handling capabilities. The only place where it fell down on acceleration was in the higher end, the passing ranges from 50 to 70, and this is something that we can achieve and do a better job on with the Mod 2.

The miles per gallon of the car were very good, in fact better than the Federal average for a car in its weight class. However, General Motors penalized us because they felt the engine was not a high enough horsepower for that class, and they tested the automobile against a car about a 1,000 pounds lighter.

In any event, from what we learned from the test we came back and made some additional modifications and now our 3,200 pound car will do 0 to 60 in 17 seconds and achieves a 30 mile per gallon combined mileage, which means about 40 miles per gallon on the highway and in the low 20's in town.

I guess to put this in perspective, for a 3,200 pound car that's about the same weight as a mid-sized station wagon, so you're talking about a large family car that can achieve these kinds of things. We have run it interchangeably on a variety of liquid fuels. That's an area that we have really completed work on.

In terms of what's happening right now, the Mod 2 parts are arriving and being checked over to make sure that they conform to the specifications of the design. I'm happy to report that John Deere Corp. is manufacturing the blocks for the Mod 2 in their production facilities out in Illinois and Iowa. We are now negotiating with them to expand that involvement to manufacture the crankshafts as well, another major engine component.

So if we are fortunate enough to have the Mod 2 do the kinds of things that we think it will, we do have an entity capable of producing these things in a production fashion.

I guess the only other thing that I would expand upon that has happened in the past year since we last saw each other was this involvement of Valmont Corp. This is a very interesting concept because it uses a coal-fired fluidized bed and a simple, fairly simple heat transfer heat pipe; and it gives the opportunity for a Stirling engine to sit in place and operate virtually directly from coal. And we're looking at probably a thousand——

Senator FORD. That's on page 10 of your testimony.

Dr. LAWRENCE. But all the promise is still there, Mr. Chairman. We don't see any major roadblocks that say it can't happen, and the industrial interest is certainly increasing.

Senator EVANS. Well, in fact, that was going to be my next question. Are the automobile manufacturers showing some interest finally?

Dr. LAWRENCE. I have to say that we have learned a great deal about them, and I think they've learned a great deal about us in the past year, and I think it's very positive on both sides. They are certainly not in a position due to the status of the technology to make any commitment to Stirling at this time, but I have to commend General Motors for the help that they have been to us. They have been very supportive. They have spent quite a bit of their own money working with us, and it's been a very supportive relationship on their part. Their research people continue to interact with us on the design and the component things having to do with Mod 2. So I think it's a very healthy relationship.

Senator **Evans**. What is your expectation—I know how many roadblocks sometimes get in the way between good ideas and even good prototypes and production models. Wankel was a good example of a very promising prototype that ran into a whole lot of problems down the line.

What's your expectation? What would you see as the most likely time scale between where you are now and what you expect out of the Mod 2 and what might evolve then toward eventual production use of an engine like this?

Dr. **Lawrence**. The key milestone, of course, Mr. Chairman, is to achieve with the Mod 2 the kinds of things that we believe we can achieve: A manufacturable engine at the right cost that has all of these technical aspects and that will meet all of the goals of the legislation.

At that point in time I frankly would hope that we not move immediately toward the automotive introduction because I think these engines need to be shaken out in smaller, less visible markets that are a little more forgiving. The consumer market is a very, very tough one.

I would hope that our first uses would be things like generator sets and perhaps heat pumps and small industrial units. Gain the operational understanding, get through the warranty periods and understand more about what happens when you put the engine into average everyday people's hands. And when that confidence builds to the point where it looks like the automotive industry could in fact put them into use and have them stay in the marketplace, then move that way. And, of course, that means that we need to maintain our relationship with people like General Motors all during that particular time period.

My guess is if we're successful at everything and without meeting any major roadblocks, I think you could see them being seriously considered for automotive use in the early 1990's.

Senator **Evans**. This may be an unfair question, but your appearance here comes right on the heels of an extended hearing this morning on automobile fuel efficiency standards before another subcommittee of this committee. Do you have any commentary on whether we ought to be interested in relaxing, leveling off, retreating, or in advancing on fuel efficiency standards?

What's reasonable, I guess, what's reasonable to expect for the automobile industry to do?

Dr. **Lawrence**. I'm afraid that I couldn't speak as an expert at all on that, Mr. Chairman. I would hope that if we're successful with the Stirling engine, we're going to be 30 to 50 percent better in gas mileage across-the-board, depending on the weight of the car and the installation, and you wouldn't need fuel efficiency standards. So with luck we may get to that point.

Senator EVANS. And I understand that you have a wide range of alternative fuels that presumably could be utilized?

Dr. LAWRENCE. Yes, sir. The engine itself operates—it's alternately heating and cooling an enclosed gas, and so the heat is transferred from the outside, and we actually have an enclosed flame that sits on top of the engine, and that flame just burns any liquid fuel that comes to it.

Senator EVANS. So it's continuous burning and as a result less polluting?

Dr. LAWRENCE. Exactly, yes, sir.

Senator EVANS. Senator Ford.

Senator FORD. Thank you, Mr. Chairman.

Mr. Franta, let me ask you a couple of questions. You talked a bit about indoor pollution a moment ago. Don't we have the air exchangers on the market now to solve the indoor air pollution?

Mr. FRANTA. There are air-to-air heat exchangers available that do solve part of the problem, although the distribution of air and the health impacts in the sources of the problem which are often from building materials that we're specifying and how that all interacts is what we would like to know more about as to how we as architects then can better design buildings to reduce indoor pollution. And the air-to-air heat exchangers are one means of reducing air-to-air pollution or air pollution in buildings. They could be more efficient, but there are products available, yes.

Senator FORD. Did you ever design a school without a window?

Mr. FRANTA. I haven't, no.

Senator FORD. Have you seen one?

Mr. FRANTA. Yes.

Senator FORD. Most of them are in this day and age, the last 10 or 15 years. Most schools have no ability to open any kind of window, so it's all indoor. It's either heating or air conditioning, and if they break down, the kids go home.

Your system integration, are you talking about what we refer to sometimes as a smart building?

Mr. FRANTA. What we're looking at there is a lot of times the sum of the parts of the energy uses in a building do not add up to the whole building energy use, and as architects we're trying to orchestrate the design of all of the materials and building components to put it together in an energy efficient manner.

And I think what we've seen the Department of Energy do in the past is use or concentrate efforts on individual building components where what we're trying to do is look at it as the components relate to each other and what the total energy performance is. So it does relate to smart buildings.

Senator FORD. Of the amount that you referred to as it relates to research how much is the Government putting in and how much is private enterprise putting in?

Mr. FRANTA. I'm sorry. Related to?

Senator FORD. You said $900,000 Government was not going to fund a moment ago. How much was private enterprise going to put in, private enterprise putting in to match the $900,000?

Mr. FRANTA. Well, I'm not sure of the total numbers and who's exactly doing what. The American Institute of Architects has put in $2 million in technology transfer activities to help get——

Senator FORD. Over what period of time have they put that in?

Mr. FRANTA. Since 1981 to the current.

Senator FORD. OK. I just wanted to get that point in so that you didn't act like you wanted it all from the Government, that you weren't putting in your part or putting in your share.

Dr. Lawrence, I was interested in a couple of items in your statement. Is one of your problems that industry here is just waiting for foreign governments to develop their engines and then buy up the patent or buy the cars from them basically or buy the engines from them? Is that one of your major bumps in the road or roadblocks or whatever?

Dr. LAWRENCE. That certainly is one of them, Senator Ford. I think the history of the automotive industry's attempts at engine innovation in the marketplace has been a very rough road, mostly because the consumers just don't put up with the vagaries that a new engine has, of not knowing about the maintenance; for instance, the things we've just recently with the diesel engine that General Motors had attempted to innovate. So it's a lot safer for them to let a foreign entity go through that phase and prove out an engine and then buy the engines from overseas.

Senator FORD. Is Japan the biggest innovator along that line of any country?

Dr. LAWRENCE. Japan and Germany. They're about equal.

Senator FORD. About equal?

Dr. LAWRENCE. Yes, sir.

Senator FORD. Would it be safe to say that Japan is totally dependent upon petroleum products and, therefore, they have to work a little harder to reduce their use of their dependence on foreign products? Or is it that we seem to have an insatiable appetite for bigger and fewer miles to the gallon?

Dr. LAWRENCE. I think that's right, Senator. The numbers I've seen say that the Japanese are more than 90 percent dependent on imported oil, so they certainly have more incentive. I think from our standpoint our balance of trade deficit could be substantially improved with revolutionary products as well as backing out the foreign oil with something like this.

Senator FORD. Well, our balance of trade with Japan took another tremendous blow in April so we're not faring very well in that area.

On page 10—well, let me just make this statement. Most people, I think, when they start talking about engines they think about automobiles. Your engine covers a broad spectrum, and I was very much interested in your statement that the engine design has a fire and would burn any type of petroleum or any type of fuel. And you talk about how the fuel efficiency represents a sizable advantage to the economics of a portion of the farming community.

Dr. LAWRENCE. That's right, Senator.

Senator FORD. Boy, they need help.

Dr. LAWRENCE. Yes, sir, they do.

Senator FORD. And by using inexpensive coal compared to petroleum products to burn in a fluidized bed. Now, does your Stirling engine as it relates to fluidized, is that the fluidized combustion bed that I'm talking about?

Dr. LAWRENCE. Yes, sir, it's the one you've heard about.

Senator FORD. Is this similar to what we're trying to demonstrate now as it relates to generating facilities; is it the same basic principle?

Dr. LAWRENCE. It's considerably smaller, but it's the same basic principle, yes, sir.

Senator FORD. All right. And you look at pumps for irrigation, things of that nature. Small industrial or large industrial operations?

Dr. LAWRENCE. Well, the engine itself, the engine class that we're building now is 80 horsepower, so it would be in that range, and you could put two or three of them together, of course. But the system that Valmont has been working on with us starts with a coal-fired fluidized bed, and then since the Stirling engine itself is an external heated engine, it takes the heat from the fluidized bed and runs the engine with the heat from that. So what you wind up with is you start from coal and you wind up with an engine with a shaft turning, and it can drive anything that's economically viable with it.

Senator FORD. Under these circumstances is your engine basically maintenance free or a reduction in maintenance?

Dr. LAWRENCE. Well, at this point in time in its development cycle it still takes a reasonable amount of maintenance. I think General Motors mentioned after its month-long sequence that it was remarkably reliable considering its stage of development.

Senator FORD. Is that one used in the Celebrity?

Dr. LAWRENCE. We will be putting it into a Celebrity.

Senator FORD. Did they use it with a car on the road?

Dr. LAWRENCE. We had it in an AMC Spirit that we gave to them, and they then took that car and test drove it on the track. They put it on the dynamometers. They put it into high temperature wind tunnels and tested it through all these things.

Senator FORD. But they will then use this system in their Celebrity?

Dr. LAWRENCE. We will be putting the Mod 2 in a Celebrity for test.

Senator FORD. When will that be? Will that be in this fiscal year?

Dr. LAWRENCE. It goes into the Celebrity in fiscal year 1987.

Senator FORD. 1987?

Dr. LAWRENCE. Yes, sir, that's the final step in the program.

Senator FORD. That's very interesting. I'd like to see you funded a little faster so it would be an American concept instead of us waiting for others to do their work and then we just buy it from them, you know. I think we have much smarter and more talented individuals who could accomplish the end result. We always seem to be waiting on the other fellow to give us what we know we can produce, and they wind up having the advantage, the patent, and they sell it all. And I look at the auto energy fuel efficiency that we have today.

One company has met their fleet mileage; the other two have not. And it's surprising that the one that has purchased most of its engines from outside the borders of the United States in order to accomplish that fleet mileage average. And I think others are going to that probably to catch up. And now in order to get ahead that one has gone to Korea and getting ready to enter into a cooperative venture, I think.

And I say to you—is it Franta?

Mr. **FRANTA**. Yes.

Senator **FORD**. Why don't you scrutinize this building before you leave and see how fuel efficient this building is and give us a report on that? I'd love to see that, Mr. Chairman, see how well it comes out.

Mr. **FRANTA**. I've been visiting other Senators and Representatives, and I've been turning out lights all day it seems.

Senator **FORD**. Turning off lights?

Mr. **FRANTA**. Turning off the lights, yes.

Senator **FORD**. I thank you, Mr. Chairman, for the opportunity, and I'll buzz on some place else.

Senator **EVANS**. Thank you.

If there are no other questions, we do appreciate very much your appearance here. It will be very helpful in the development of our budgetary authorizations as we go forward.

Mr. **FRANTA**. Mr. Chairman, can I clarify one thing? Your question on the glazing, I just wanted to reiterate that our concern here is that our priority would be to look at the building components as how they relate to each other and what the total annual energy use would be in buildings as we change building components and building systems rather than in isolation, which is the tendency for most product manufacturers to look at their product individually.

Senator **EVANS**. OK. Thank you very much.

Mr. **LAWRENCE**. Thank you.

Mr. **FRANTA**. Thank you.

Senator **EVANS**. The hearing is adjourned.

[Whereupon, at 3:20 p.m., the hearing was adjourned.]

APPENDIX VII

Responses to Additional Questions

POST-HEARING QUESTIONS AND ANSWERS

FROM SENATOR JEFF BINGAMAN

FOR MISS D. FITZPATRICK

RELATING TO

FY 1986 AUTHORIZATION HEARING

BEFORE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

SENATE ENERGY AND NATURAL RESOURCES COMMITTEE

MAY ~~13~~ 14, 1985

ENERGY OUTLOOK

Question 1: The Energy Information Administration, in their annual *Energy Outlook*, estimated that our dependence on foreign sources of petroleum will double by 1995. Given these projections, do you think we are devoting enough attention to renewable energy technologies? I am concerned about the trend in this Administration to reduce the emphasis placed on these important programs. Can we afford as a nation to reduce our commitment to providing the best possible energy mix to meet our future needs?

Answer: The actual level of oil imports in the future will have a strong dependence on the relative price of oil versus alternative energy sources. The Department is funding a balanced program of renewable energy R&D, that is intended to provide the technology base for longer term improvements in the competitiveness of renewable energy options. It is our view that the amounts proposed for R&D in this area are adequate to sustain and build upon the scientific and technical momentum achieved to date. The Department is committed to continuing its efforts in establishing a technology base for a number of renewable technologies which offer promise of diversity within the competitive marketplace.

CONTINUED PROGRESS IN RENEWABLE

Question 2: I understand we have made significant progress in many renewable technologies including geothermal and solar. However, faced with shrinking federal dollars, how can we continue to ensure continued progress in these areas?

Answer: Industry has moved quickly to accept the challenges of bringing competitive technologies to the marketplace and has internally invested funds in technology development. Adoption of the Administration's policies regarding tax reform and deregulation of the marketplace are essential to establishing a competitive energy and economic environment which fosters continuing innovation and risk taking within industries such as renewable energy. With regard to Department of Energy funding, the Department is concentrating Federal funds where they are most effective--in supporting R&D efforts where the potential payoff is high, but which private industry cannot be expected to pursue alone because the results are difficult to predict or a return on investment would require an exceptionally long time to be realized. This re-direction has allowed the Department to continue to fund R&D at a rate which has remained stable for the past several years and which should provide the private sector with an increasing range of competitive technologies.

LONG RANGE GOALS

Question 3:	What are the Administration's long range goals for these renewable programs? Does the Department of Energy have a commitment to continue support for renewable technologies as long as progress can be demonstrated?
Answer:	The Department supports continuing its investment in these technologies in cooperation with the private sector. A considerable effort has been applied to developing a consistent view of the specific technology development objectives which must be met in order to advance the technology options towards viability. A copy of the Renewable Energy Outlook is provided as a summary of the process employed for examining priorities throughout this diverse group of technologies. Technology specific multiyear program plans, based upon the results of this comprehensive study, are being prepared to provide additional insights as to the time phasing of specific objectives for the various technical options.

U.S. Department of Energy
Office of Conservation and Renewable Energy
Deputy Assistant Secretary for Renewable Energy

Renewable Energy Research and Development Outlook

Volume 1

October 1985

PRIVATE VERSUS FEDERAL SUPPORT

Question 4: Do you really think the private sector can achieve the same significant progress in the alternative energy areas we have had thru federal support?

Answer: Federally supported industrial, university, and national laboratory researchers have made significant advances in our understanding of the renewable energy resources and the technologies for converting them to useful and viable energy commodities. Private industry has been equally impressive in pursuing the responsibilities they do best - developing specific products and manufacturing facilities and securing private capital. They have also demonstrated research expertise in that many significant advances were made by industry researchers, both under DOE contract and under private funding. The industry has proven that it is capable of contributing to technological momentum. If the regulatory impediments to a competitive marketplace can be further reduced, the prospects for additional industrial success look particularly bright for renewable energy.

Question 5: We know we are increasing the percentage of our energy requirements supplied by alternative energy sources. What type of reporting system is there to keep track of this increased contribution? Can these systems be improved?

Answer: The Energy Information Administration (EIA) does not operate a reporting system to track solely the contributions of alternative energy sources. The EIA does perform periodic studies to estimate the contributions of individual alternative energy sources. Studies have been performed on wood energy consumption, solar collector manufacturing and installations, residential energy consumption of alternative energy sources, and electric utility generation from geothermal, hydro, and wind.

Because data on these energy sources are very diverse, they are very expensive to collect. The cost tradeoffs of these collections with more prominent energy sources has resulted in a minimization of activity in these areas. This plus a minimum of public interest in these areas resulted in the EIA canceling its solar survey, the Solar Manufacturing Activity Survey, in Fiscal Year 1986.

RENEWABLE ENERGY'S FUTURE POTENTIAL

Question 6: I am concerned that the Department has underestimated renewable energy's current contribution and future potential. I think it is one of our most promising growth industries. What action have you taken to provide for the dissemination of information on these technologies? Can we improve our PR efforts related to alternatives in order to increase public awareness and interest?

Answer: As indicated in its forecasts, the Department agrees that the potential of renewable energy is significant. It is further our view that the renewable industries may well represent a significant growth opportunity for industry. The Department has integrated a broad variety of mechanisms into its programs to ensure that research results are made available to industry and energy decision makers in a timely manner. In light of the role of industry in marketing technology, our efforts in public information are somewhat more modest but play an important role in stimulating dialogue between energy suppliers and consumers. For example, the Department funds the operation of the Conservation and Renewable Energy Inquiry and Referral Service (CAREIRS) which provides general information in response to some 40,000 requests annually from the public. Additionally, we have financially supported the operation of the National Appropriate Technology Assistance Service (NATAS) which serves a dual function: providing assistance to businesses entering the conservation and renewable energy field and providing specific problem solving assistance to parties interested in specific applications. Finally, we are especially pleased with the success of our awards program initiative which has mobilized the interest of industry and States throughout the Nation in recognizing exemplary conservation and renewable energy programs and applications. These mechanisms have proven most effective in providing a continuing general stimulus to the public and in setting the stage for the specific marketing activities of industry.

TECHNOLOGY TRANSFER

Question 7: I am particularly concerned about ensuring that the results of our basic research efforts in this area are transferred to the private sector for commercialization. What mechanisms and/or programs does DOE have to accomplish this?

Answer: The Department has incorporated a variety of technology transfer mechanisms into the renewable energy programs to facilitate the transfer of research to the private sector. These undergo periodic assessment and we make every effort to continue to improve their effectiveness. In the broad sense, technology transfer represents a major component of the Department's program. Mechanisms range from involvement of industry in the planning of the program, to operating a number of facilities as national user facilities where industry can utilize the unique equipment and laboratories for their own experiments, to securing industrial participation and collaboration in research sponsored by the Department. Additional mechanisms include operation of the SERI Technical Information Program which provides efficient and timely industrial access to research in progress as well as participation of Departmental researchers in numerous meetings and symposia to provide for that personal dialogue and exchange of views required for real transfer of knowledge between individuals.

GEOTHERMAL HOT DRY ROCK

Question 2: I am concerned with the reduction in the Hot Dry Rock Program carried on at Los Alamos. With the budget you have recommended, what happens to the International Energy Agency Agreement regarding Hot Dry Rock research?

Answer: The reduction in direct cost to each partner is an important benefit of international R&D cooperation. The Federal Republic of Germany and Japan have both been providing financial support to the Los Alamos National Laboratory (LANL) Hot Dry Rock program, under the auspices of the International Energy Agency. In addition, scientists and engineers from West Germany and Japan have been assigned by their governments for extended periods as active members of the LANL Hot Dry Rock research team. Japan has signed a one-year extension to the most recent tripartite agreement which expired on September 30, 1985. The Administration's request for funding for the geothermal Hot Dry Rock program in Fiscal Year 1986, combined with current foreign support, provides adequate resources to maintain the momentum of this important energy research program.

FUEL CELLS FOR TRANSPORTATION

Question 9: Is the department committed to the development of fuel cells for transportation purposes? I am particularly interested because I understand General Motors is willing to cost-share at the 50% level with the government for such an effort. What is your level of commitment in terms of budget resources?

Answer: The Department is conducting R&D on fuel cells for a number of applications including transportation purposes. Our transportation related fuel cell R&D is managed by Los Alamos National Laboratory. We have had discussions with General Motors and shared our technology development with them. In FY 1986, the Department is requesting $500,000 for continuing the development of fuel cells specifically for transportation purposes. We believe, however, that the Department's primary contribution will be in basic fuel cell technology that can be applied by many industries for their own uses in developing specific products. In 1986 the Department requested $10.4 million for advanced (next generation) fuel cell development in the Fossil Energy R&D budget. Most of the knowledge gained from that work will be transferable to transportation companies such as GM.

POST HEARING QUESTIONS AND ANSWERS

RELATING TO THE

MAY 14, 1985 HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES

UNITED STATES SENATE

WITNESS: DONNA R. FITZPATRICK

QUESTIONS FROM SENATOR DOMENICI

CONSERVATION

Question 1: To a large extent, the success of DOE's research and development programs in conservation depends on the degree to which private industry utilizes the results of such research. Can you give us a measure of how effectively DOE's research is being transferred to and utilized by the private sector?

Answer: The prompt and effective transfer of results from federally funded research and development activities to private entrepreneurs, innovators, businesses, and industry is a major priority of the Conservation program. Technology transfer activities have become an increasingly large part of the budget, and close partnerships with the private sector are maintained both in program planning and implementation. By keeping the industry which will use the technologies involved in our program efforts, research results are transferred more effectively.

There are many examples of the effective transfer of DOE-funded research results to the private sector. Technology being developed for ceramic components in the automotive gas turbine program has already been picked up by the private sector for improved turbocharger commercialization. Basic research on silicon carbide fibre ceramic composites from our Advanced Materials Program has been picked up by the tool bit industry and successfully commercialized. Research in the Energy Conversion and Utilization Technologies program on nickel aluminides has been successfully transferred and licensed to the

Cummins Engine Company. This new class of intermetallic materials shows extremely high yield strength at high temperature operation, which is ideal for the interface of the piston ring and cylinder liner of diesel engines.

In industrial energy conservation, DOE has supported research on over 200 technologies in cost-shared contracts with private industry. Of these, 23 are now complete and being commercialized by industry alone. These 23 technologies have saved an accumulated 116 trillion Btu's and have penetrated the market sufficiently to push the rate of savings to 40 trillion Btu's annually. This energy saved is worth approximately $400 million to the consumer. Typical projects include foam-to-replace-water in textile finishings, high temperature ceramic heat recovery units operating at 2600° F, and low speed diesel cogeneration systems.

Research into building equipment has been incorporated into a variety of products. Some of these efficiency improvements leading to new or improved marketed products include:

50% improvement in heat pump water heaters
75% improvement in incandescent lamps via new prototypes
25% improvement in fluorescent lamps through solid state ballasts
15% improvement in gas burners through an adjustable power gas burner.

Condensing furnaces are now being marketed that operate at efficiencies of 90-95% compared to the 63-75% for the average new non-condensing systems.

QUESTIONS FROM SENATOR DOMENICI

CONSERVATION

Question 2: Research on buildings and industrial energy conservation are cost-shared with the private sector. On average, what portion of the research is funded by the private sector?

Answer: The Office of Conservation and Renewable Energy requires significant cost-sharing on the part of the private sector wherever possible in order to maximize the effect of limited budget resources. However, no specific percentage is required, due to the varying capabilities of individual contractors.

In the industrial sector, percentages range from 5 to 60, with an average of approximately 25%. In buildings research and development most cost-sharing percentages range from 5 to 20, with an average of approximately 15%. There are specific examples of contracts where the cost-share runs as high as 45%.

QUESTIONS FROM SENATOR DOMENICI

CONSERVATION

Question 3: DOE's program in Stirling engine development in zeroed in the FY86 budget request. On what basis was the decision made to terminate this program? What were the results of the industry evaluation (by General Motors and John Deere) of the Stirling engine?

Answer: By the end of FY 1985 sufficient technology development will have been accomplished and adequate test data will be available from engine tests and characterizations, in addition to the results of the industry evaluations, to allow industry to decide whether commercialization efforts should be carried out. The MOD II design and component development work completed in FY 1985 will assist industry in making such decisions. Follow-on efforts, including finalization of the MOD II design, should be supported by industry.

Although the industry evaluations were successful, both evaluations (General Motors and John Deere) presented no clear recommendations on whether or not continuation of the program would make business, economic, or technical sense. The evaluation reports contain straight-forward evaluations of test results, which essentially confirm that the MOD I performance meets the goals established for that design. However, the results did not indicate any change in industry's position regarding the viability of Stirling engine technology as an automotive powerplant. To date, the automotive industry has shown no interest in continuing development of the Stirling engine.

QUESTION FROM SENATOR DOMENICI

CONSERVATION

Question 4: How successful has DOE's vehicle propulsion program been in achieving a 30% improvement in fuel economy? Which engines hold the most promise of meeting this goal?

Answer: Although neither the gas turbine nor the Stirling engine developments have reached the stage where final engine designs can be fully tested on dynamometers, tests have been run on components and early designs in test rigs. Based on present analyses and predicted performance parameters, the fuel economy of a 3,000-pound car, powered by either of the gas turbine engine designs, will be in the 42-45 mpg range, and powered by a Stirling engine of the MOD II design will also be in the 42-45 mpg range. Both of these propulsion systems will meet the 30 percent improvement in fuel economy goal.

QUESTION FROM SENATOR DOMENICI

CONSERVATION

Question 5: What are the program management costs associated with the vehicle propulsion program? Who manages the program?

Answer: Under an Interagency Agreement, personnel from the NASA/Lewis Research Center serve as the technical project managers for the vehicle propulsion program activities, and also participate in the performance of associated supporting research and technology efforts. The costs for these services, which are spread among the automotive gas turbine project, the automotive Stirling engine project, and the heavy duty transport project, are approximately $2.9 million per year.

QUESTION FROM SENATOR DOMENICI

CONSERVATION

Question 6: The electric and hybrid vehicle R&D budget for FY86 is $2 million below the FY86 funding, yet program plans appear to be expanding in terms of battery testing, a.c. propulsion work, and the prototype van test bed activity. What areas in the program have been reduced to accommodate the $2 million budget reduction?

Answer: Program areas that have been reduced include: advanced vehicle technologies such as nickel-cadmium batteries, reduced by $620,000; integration and test of electric vehicle improvements in the field and in the laboratory, reduced by $1,829,000; and development of batteries and propulsion systems, reduced by $105,000. The nickel-cadmium battery conceptual design phase will be completed using FY 1985 funding. The field testing of the second round of improved batteries and components will be completed using FY 1985 funding. Any additional improvements will be carried out by the private sector. The reduction in funding for battery and propulsion systems results from completion of some of those programs using FY 1985 funding.

QUESTIONS FROM SENATOR DOMENICI

CONSERVATION

Question 7: DOE's activities in ceramic materials research and in biological separations are complimentary to research being done under the Bureau of Mines Strategic and Critical Materials research program. How are these programs being coordinated to avoid duplication and provide for effective use of lab facilities?

Answer: Ceramic materials coordination with the Bureau of Mines Strategic and Critical Materials research program is conducted through the Idaho National Engineering Laboratory (INEL). Representatives from EG&G, the contractor operating INEL, are invited to the regularly scheduled bi-monthly management meetings of the Ceramic Technology for Advanced Heat Engine program; they also attend the annual contractor coordination meetings sponsored by that program. In addition, DOE staff have visited with INEL in order to ensure coordination and effective use of laboratory facitilities. In the area of biological separation, INEL is again the primary focus of coordination. INEL was specifically selected to conduct the research in order to effect direct coordination between the two programs. Duplication of research results in the area of ceramic materials research between DOE and the Bureau of Mines is avoided by attendance at the annual meeting of the Interagency Coordination Group on Structural Ceramics that meets in the fall. Representatives from NSF, DOE, DOD, DOI, NBS, and others attend the meetings expressly to find out what ceramics research is being conducted Government-wide.

QUESTIONS FROM SENATOR DOMENICI

ENERGY CONVERSION AND UTILIZATION TECHNOLOGIES

Question 1: How do we stackup, in comparison to foreign countries, in terms of our industrial competitiveness in energy productivity and advanced industrial processes? What will it take to convince our industries to adopt new, more energy-efficient technologies?

Answer: In terms of industrial productivity and advanced industrial processes, the U.S. is under increasing foreign pressure in its efforts to remain competitive. According to the U.S. Patent and Trademark Office, residents of foreign countries currently receive 42% (1984) of U.S. patents. Twenty-five years ago foreigners received only 17% of U.S. patents. The following table, which indicates the major sources for improved process technology for several basic industries, indicates that there is an obvious and legitimate concern in the U.S. that we are losing our technological lead in several major industrial areas.

Table 5.2.6 Principal Sources of New Process Technology to Energy Intensive Industries

Industry	Principal Sources of New Process Technologies
Steel Industry	Japan and European countries
Chemicals Industries	United States
Petroleum Refining	United States
Paper Industry	Scandinavian countries
Aluminum Industry	United States
Cement Industry	Japan
Textile Industry	Switzerland, West Germany, Japan
Food Processing Industries	European countries and United States

Source: "1985 U.S. Industrial Outlook," USDOC, and "Foreign-Impacted Equipment Industries," Engler, Bailly & Company, 1985.

A recently completed study conducted for the Office of Industrial Programs concerning a review of government sponsored industrial energy conservation research, development, and demonstration programs in the Federal Republic of Germany (FRG), France, Sweden, and the United Kingdom described their programs and respective levels of funding (see Table below). These countries (in fact, all the IEA countries) support the market mechanism as a principal means of achieving enhanced energy efficiency. The amount of government intervention that is justified to correct market inefficiencies and to remove market barriers, however, varies considerably.

Annualized RD&D Budgets in Industrial Energy Conservation

Country	Annualized Budget (in millions of U.S. Dollars at Jan. 1985 exchange rates) 1985 Budgets
FRG (Federal Republic of Germany)	10.2
France	12.4
Sweden	22.1
United Kingdom	28.1
United States	31.9

The primary incentive for industries to adopt more energy-efficient technologies is the economic incentives such technologies hold. DOE's Industrial Conservation Program continues to focus its activity on research which increases the energy efficiency of industrial operations.

The previously referenced study (by Hagler, Bailly & Co.) suggests that the approach taken by the countries reviewed (Germany, France, U.K. and Sweden) has increasingly been to focus attention on "high-quality" research and development investments, as the following excerpts indicate:

> The search for "high-quality" research and development was fueled by a growing recognition in all four countries that industrial energy conservation can increase industrial productivity.
>
> In their search for "high-quality" research and development investments, the four countries have shifted the emphasis from "saving" energy to promoting the efficient, cost-effective use of energy. The search for "high-quality" investments has been a primary motivation in all four countries, which implies that research and development programs are more selective and result not only in marginal improvements, but involve substantial redesign or changes in process configuration.

This supports the current U.S. program which concentrates on energy research and development in areas where the incentives for and availability of private investment are severely limited or non-existent. In these areas, competitive rates of return on investment cannot be realized by private firms, either because they are difficult to predict or highly risky, or because they would provide an exceptionally long time to be realized. It is in these areas that the concentration of U.S. R&D efforts can be most beneficial by developing technologies that industry will embrace as cost-effective and energy efficient.

QUESTION FROM SENATOR DOMENICI

ENERGY CONVERSION AND UTILIZATION TECHNOLOGIES

Question 2: How are DOE's programs in energy conversion and utilization coordinated with the engineering research and materials processing research programs conducted within Basic Energy Sciences Division of the Office of Energy Research? Obviously, there is a lot of cross-fertilization that could be accomplished between these offices.

Answer: There are four forms of coordination extensively used between the Energy Conversion and Utilization Technologies (ECUT) program and the programs in Basic Energy Sciences (BES):

1. Informal discussions between the staffs of both programs.
2. Intra-laboratory information exchange, such as at Oak Ridge National Laboratory, where researchers work on both ECUT- and BES-funded projects.
3. The Energy Materials Coordinating Committee (EMaCC) Annual Report, which details materials research projects throughout DOE, and monthly EMaCC meetings.
4. Yearly publication of abstracts of BES research projects that names the principal investigators; ECUT staff reviews the report for possible research opportunities.

QUESTIONS FROM SENATOR DOMENICI

Wind Energy Systems

Question 1:	A number of privately owned "wind farms" have been in operation for a number of years. What has been their operational experience in terms of reliability, capacity factors, etc.? What does it cost to produce electricity at these sites and what is the price paid for it by utilities? How important was the renewable energy tax credit in encouraging investment in these sites? Will the expiration of this tax credit spell the end of such development in the near-term?
Answer:	Reliable data is only just beginning to emerge regarding wind farm operation. A recent study involved the collection of data over a 3½ month period in 1983 from fifty 50 kW wind turbines on a farm in Altamont Pass, California. Analysis of this representative group of turbines showed that the cumulative average "capacity factor" of these mature turbines was 0.33 and that the more significant cumulative average "utilization factor" was 0.67. The definitions of these performance measures are:

Capacity Factor - the ratio of the actual energy derived from the wind turbine to the energy it would provide if it operated at maximum power output over the entire time interval of interest;

Utilization Factor - the ratio of the actual energy derived from the wind turbine to the energy it would provide if it operated at its maximum power output over the times when the wind speed is within the wind turbine's operating range (between cut-in and cut-out).

The only measure of long-term turbine reliability derivable from the study is the "availability" which is defined as:

Availability - the fraction of total time that the wind turbine is available for operation.

For the fifty 50 kW turbines, the cumulative (three and a half month) average availability was 90%.

The costs at which wind generated energy is produced and the prices paid by utilities are not generally known. However, for one large wind farm in the Altamont Pass in California, the estimated cost of energy produced -- without tax credits -- is 9.5¢/kWh. The price paid by the utility for this energy varied by time of day and by season of the year but the Summer average was approximately 6.4¢/kWh and the Winter average was 7.5¢/kWh.

The combined Federal and State tax credits have been a major factor in enhancing the economic attractiveness of investments in ventures of this type. The expiration of the Federal credits will likely result in a reduction in the number of such ventures and a consolidation among wind turbine manufacturers. Joint industry R&D and industrial scaling up activities may combine to improve the economics and reliability of wind turbines and serve to offset this potential decline in commercial activity over the mid-term.

QUESTIONS FROM SENATOR DOMENICI

Wind Energy Systems

Question 2: Please summarize the historical development of the Mod-5 multi-megawatt turbine development program and the present status of that program.

Answer: The Mod-5 program was established in 1979 to develop large, utility class, horizontal axis wind turbines that would incorporate advanced technology and represent a significant improvement in terms of performance, cost, and reliability over earlier system (i.e., the Mod-2). Two parallel cost-plus fixed fee contracts were issued competitively, one with the General Electric for the Mod-5A and the other with the Boeing Aerospace Company for the Mod-5B. In November 1983 General Electric decided to withdraw from the program, apparently due to unfavorable market conditions and technical uncertainties at the time. GE has documented the results of their completed engineering and design studies, and their contract has been closed-out.

Boeing is currently under contract with the government to complete the design, fabrication, and installation of the Mod-5B. Most of the hardware subcontracts have been awarded and are in fabrication. Hawaiian Electric Industries has signed a cooperative agreement with NASA for the purchase of the Mod-5B, tied to a sliding scale based on performance of the machine during acceptance testing. The purchase price is expected to be about $4 million.

Certain factors have caused DOE to recommend close-out of the Mod-5B advanced multi-megawatt wind turbine development program without turbine construction includes: an uncertain market for very large scale machines such as the Mod-5; increased project costs and weak industry cost-sharing; and the apparent current intention of industry to progress from small to intermediate size turbines.

These government efforts have resulted in much new knowledge which has been applied throughout the wind energy industry. A complete Mod-5 detailed design with engineering documentation will allow for future use of resulting trade-off studies, engineering analysis and advanced design techniques by the entire wind energy industry.

QUESTIONS FROM SENATOR DOMENICI

Wind Energy Systems

Question 3:	Please describe the nature and extent of fee-paid testing at the Wind Energy Research Center.
Answer:	The SERI Wind Energy Research Center has played and continues to play a key role in supporting the wind turbine industry. Many small manufacturers entering the wind business do not have needed test facilities and capabilities and rely on Rocky Flats for support. The SERI Wind Energy Research Center performs testing for industry and provides a focal point for generic technology research studies on a broad range of machine sizes and configurations, and on environmental and other systems issues. When requests for support from either private companies or other government agencies involve significant work, it is done on a fee-paid basis. In FY 1985 this fee work will total about $300-400K.

QUESTIONS FROM SENATOR DOMENICI

TAX CREDITS

Question 1: What is the DOE position on the possible extension of the conservation and renewable energy tax credits? Has the DOE been involved in the development of the Administration's tax package as the Secretary committed during his nomination hearing?

Answer: The general issue of tax credit extension is currently under review as part of the Department's analysis of the overall effects of the Administration's tax simplification proposal. We are particularly interested how this proposal assists the Department in meeting the stated energy policy objectives of maintaining an equitable competitive balanced and diversified energy resource system. Within the overall framework of the current tax structure, credits have played a valuable role in establishing momentum and demand for conservation and renewable technologies. This, in turn, has provided stimulus to overall industrial growth and the creation of new industry.

However, the President has addressed the larger issue of a complete reform of our tax system. This reform depends on the elimination of special tax benefits, balanced by general lowering of the marginal tax rates on both individual and corporate income and capital gains. We believe that the President's tax proposals will make our tax system simpler and fairer and will provide significant impetus toward achieving a healthier and more productive economy. The lowered tax rates are expected to maintain incentives for investment in new technologies while reducing the distortions caused by the current abuse of some technologies as tax shelters rather than productive investments. In the long run, an expanding economy with incentives for productive investment is the best spur to new technologies, including conservation and renewable energy technologies. We believe, therefore, that energy conservation and the development of renewable energy will continue under the President's proposal, which we are happy to support.

The Department has had meetings with the major conservation and renewable trade associations, individual corporations and representatives of domestic energy producers to gain insight and data for incorporation into our analysis.

The Department has and will continue to provide advice to the Administration on the energy impacts of various tax simplification proposals.

QUESTIONS FROM SENATOR DOMENICI

Tax Credits

Question 2: Has the DOE analyzed the effect of the expiration of these tax credits on the manufacturers of the various technologies? If not, please provide such an analysis for the Record.

Answer: The DOE is analyzing the market impacts on the Nation's energy resource system, not on the manufacturers of various technologies. Our previous analysis has suggested that, within the overall framework of the current tax structure, investment in highly tax advantaged technologies will be adversely affected when such credits expire. It follows that producers of such technologies will experience reduced demand for their respective products. The most heavily tax leveraged renewable technologies appear to be ethanol production, photovoltaics, solar building equipment and wind; consequently, it should be expected that investments in these technologies will be significantly curtailed. However, we have not yet completed our assessment of the impact of expiration of the energy tax credits within the context of the Administration's tax simplification proposal.

QUESTIONS FROM SENATOR DOMENICI

Tax Credits

Question 3: Has the DOE analyzed the effect of the expiration of these tax credits on the ability of the manufacturers to compete in the world market? If not, please provide such an analyzes for the Record.

Answer: As noted in the previous response, an analysis of these issues is currently underway.

QUESTIONS FROM SENATOR DOMENICI

Tax Credits

Question 4: How many "tax dollars" have been spent on renewable energy technologies through these tax credits? How many "tax dollars" have been spent on conservation? What are the total appropriated funds spent in these two areas by the Federal government? In terms of "barrels of oil", how much energy will be produced, or saved, by the renewable energy and conservation technologies that have been placed in this country since 1973?

Answer: The attached table contains the estimated revenue losses resulting from claims under Conservation and Renewable tax credits. Between 1975 and 1984 the total budget authority (BA) for the Federal Program in renewable energy technologies was approximately $4 billion. During this same time period the Federal program in conservation technologies received a total budget authority of approximately $2 billion. The cause and effect relationship between Federal investments and technology diffusion is difficult to ascertain and can only be accurately assessed over an extended period of time, usually decades after a technology has achieved a substantial level of commercial market acceptance.

Using data from the National Energy Policy Plan-IV (NEPP-IV) an estimate of the renewable energy portion of total energy supply has been developed and converted to barrel of oil equivalents (BOE). From 1975-1984, it is estimated that the incremental addition of renewable energy production capacity was 1.2 billion BOE. Since these estimates were made from data developed during 1982-1983, they do not account for any of the renewable energy projects that have recently come on line such as geothermal, wind, photovoltaics, solar thermal, etc. When these additions are included, renewable energy production, over and above that which existed prior to 1975,is estimated to be 175-200 million BOE annually. The projected cumulative incremental renewable energy between 1975 and 1994 (20 years) is 5.8 billion BOE.

Concerning energy conservation, between 1973 and 1984 the amount of energy required to produce a constant dollar of gross national product declined by 24 percent. Improvements in energy efficiency alone are estimated to account for more than 60 quads of cumulative energy savings since 1973. This total equals 10 billion barrels of oil equivalent.

Attributing specific energy savings to DOE's programs, however, is difficult, if not impossible. Because DOE's role is indirect, it is not always clear how much is attributable to DOE programs and how much is attributable to actions that would have been undertaken in any event. DOE may help solve certain technological problems, for example, but the private sector is responsible for applying research results in the development of a commercial product. Moreover, many new energy conservation improvements in the market place were not originated with DOE funded R&D.

ENERGY TAX CREDITS
ESTIMATED REVENUE LOSS TO THE TREASURY
(millions $)

	FISCAL YEAR							
	1979	1980	1981	1982	1983	1984	1985	1986
Residential Energy Conservation	645	430	425	360	285	270	245	190
Residential Renewable Energy Supply		55	150	250	325	325	330	315
Business Energy Conservation	220	190	220	220	50	10	*	*
Business Energy Supply		150	180	205	250	220	210	140
Intercity Bus	NA	*	5	10	10	10	10	5
Alcohol Fuel Production	NA	50	60	60	160	215	270	305
Alternative Fuel Production	NA	5	25	15	10	10	25	25
Special Treatment of State & Local IDB's	NA	*	*	5	170	160	175	190

* 2.5 million $ or less.

Sources: Office of Management and Budget, Special Analyses, Budget of the U.S. Government, (Special Analysis G), FY 1986 (for FY '84, '85, & '86 data); FY 85 (for FY '83 data); FY 84 (for FY '82 data); FY 83 (for FY '81 data); FY 82 (for FY '80 data); FY 81 (for FY '79 data); FY 80 and earlier provide no data for FY '77 and '78.

Prepared by:	Carmen Difiglio
Office/Office Phone:	PE-15 - 252-4444
Home phone:	323-0985
Date:	March 5, 1985
Asst. Sec. Initials:	

QUESTIONS FROM SENATOR DOMENICI

Ocean Energy Systems

Question I: Are there any commercial Ocean Thermal Energy Conversion (OTEC) facilities in the world?

Answer: There are currently no commercial OTEC plants anywhere in the world.

QUESTIONS FROM SENATOR DOMENICI

Ocean Energy Systems

Question 2: What are the likely materials to be used in heat exchangers for an OTEC plant? How will fouling by animals and plants be avoided? To what degree does fouling reduce the efficiency of these plants? Are there possible environmental consequences from the anti-fouling activities associated with these plants?

Answer: The most likely heat exchanger material to be used in meeting the DOE five year research target goal for low cost heat exchangers is aluminum. Research will focus on improving the performance of heat exchangers while increasing the life expectancy of the materials used. Advancements in waterside heat transfer have the potential to cut material and labor requirements while increasing the power extracted.

Fouling by animals and plants in past experiments (such as the OTEC-1 Test Facility) has been controlled by limiting the intake velocity of the seawater and by the use of a series of grates and screens in the water supply.

The efficiency of these plants is reduced in direct proportion to the extent of fouling. DOE's experimental research in OTEC heat exchangers has established a means of measuring fouling in terms of loss of heat transfer in ft^2 hours °F, known as 'R_f'. A value of R_f of .0005 will reduce the heat exchanger power output almost 25% for an advanced heat exchanger. DOE's target value for R_f is .0001 which would reduce output by only 7%. DOE has experimentally established that chlorination is an effective anti-foulant in OTEC power systems. The EPA limit for chlorination for pristine waters is an average of less than 0.2 parts per million (PPM) in a 24 hour day and not to exceed 0.5 PPM more than once in a 30 day period. DOE's experiments have been undertaken at or below these EPA values. DOE's environmental assessments do not predict any adverse impacts at this level.

QUESTIONS FROM SENATOR DOMENICI

Ocean Energy Systems

Question 3: Has the DOE examined the environmental consequences of bringing massive volume of cold seawater to the surface of the ocean?

Answer: Through a series of analytical, numerical, and physical models, the DOE has examined the physical processes and environmental consequences of the redistribution of chemical and biological components of seawater due to OTEC operations. Results indicate that the preferred design will mix the cold seawater with the warm surface seawater and discharge the combined effluent well below the surface layer to minimize thermal effects.

QUESTIONS FROM SENATOR DOMENICI

INTERNATIONAL SOLAR PROGRAM

Question 1: What level of appropriation has been requested to implement the Renewable Energy Industry Act of 1984?

Answer: Specific appropriations were not required and have not been requested for activities in support of the Renewable Energy Industry Act of 1984. These activities will continue with existing funds and will be supported by the staff efforts of DOE, DOC, AID, OPIC, DOD, State, Treasury, Ex-Im Bank, and the U.S. Trade Representative.

QUESTIONS FROM SENATOR DOMENICI

International Solar Program

Question 2:	What activities are planned by the Department of Energy, Department of Commerce or other agencies, to promote the export of renewable energy technologies?
Answer:	A significant agenda of activities is planned in support of renewable energy exports. The interagency Committee on Renewable Energy Commerce and Trade (CORECT) will continue to meet and provide leadership. The 5 CORECT subcommittees will seek methods to educate foreign decisionmakers, to streamline and make more responsive the existing U.S. agencies involved in trade assistance, to identify issues for future trade negotiations, to optimize the economic and technological competitiveness of U.S. products, and to take advantage of the showcase opportunities available at the Renewable Energy Technologies Symposium and International Exposition (RETSIE) at Anaheim, California, in June. Over 2 dozen senior foreign energy officials have accepted invitations to attend RETSIE as guests of the Department of Commerce, to participate in special meetings with U.S. officials, and to visit renewable energy installations. In addition, an export workshop is planned for U.S. manufacturers. The CORECT committee, itself, will meet at RETSIE and will receive progress reports from the 5 subcommittees. In separate actions, technology-specific, trade assistance seminars are anticipated later in the year, similar to those already held for photovoltaics and wind. Also, the Department of Commerce will continue to execute a series of trade shows and expositions in a number of countries to assist U.S. renewable energy industry numbers to showcase their products in potential market areas.

Question from Senator Domenici

National Appropriate Technology Assistance Service

Question 1: The Department has requested $1 million to fund NATAS for FY 1986. What level of activitiy does that presume (that is, how many inquiries)?

Answer: With the requested funding, 7300 inquiries could be answered. Of the 7300 inquiries approximately 3350 tailored technical responses requiring analysis and research could be provided and 3350 responses to requests for general technical information could be prepared. In addition, 600 requests for commercialization planning assistance could be addressed, some of which may require extensive one on one interaction and followup.

QUESTIONS FROM SENATOR DOMENICI

HEALTH RISKS FROM BUILDING ENERGY CONSERVATION PRACTICES

Question: A great deal hass been said about increased health risks from building conservation practices. Has the DOE evaluated those risks? Are they significant? Has DOE prepared information for home builders on this matter?

Answer: Energy conservation practices such as reducing ventilation rates and using supplementary heating sources can elevate concentrations of indoor pollutants, resulting in increased pollutant exposures and potential health risks. DOE is conducting research to characterize indoor pollutant concentrations, to assess indoor exposures, and to evaluate health risks. The objective of this research is to provide information to builders, designers, consumers, and others to optimize both energy conservation and indoor air quality.

DOE is conducting research to characterize indoor pollutant sources and the factors which affect indoor concentrations. This research includes studying building entry mechanisms for radon gas and evaluating energy efficient control strategies to reduce indoor radon concentrations. DOE is also performing research to assess indoor pollutant exposures and to evaluate the health risks associated with these exposures, including the possibility of carcinogenic effects.

DOE and the other Federal agencies conducting research in indoor air quality, including EPA, are coordinating research activities through an interagency Committee on Indoor Air Quality (CIAQ). The CIAQ identifies undesirable overlaps in agency research efforts, ensuring the indoor air quality research of the member agencies is complementary, including research devoted to evaluating health risks.

In addition to technical reports and peer-reviewed publications, the results of DOE research have been made available to the non-research community in the following publications:

"Find and Fix the Leaks: A Guide to Air Infiltration Reduction and Indoor Air Quality Control," DOE/CE-0006, May 1981;

"Innovative Structures Program: Indoor Air Quality Fact Sheet," ORNL/SUB 69741-02, August 1981;

"Heat Recovery Ventilation for Housing: Air-to-Air Heat Exchangers," DOE/CE/15095-9, March 1984;

"Update: House Tightening Under BPA's Home Weatherization Program," published by the Bonneville Power Administration, August 1984;

"Home Weatherization and Indoor Air Pollutants," DOE/BP-310, November 1984;

"Indoor Air Quality Guide for Designers, Builders, and Users of Energy Efficient Residences," Sandia Report 82-1773; and

"Indoor Air Quality Environmental Information Handbook: Combustion Sources," DOE/EV/10450-1.

QUESTIONS FROM SENATOR DOMENICI

BUILDING ENERGY SYSTEMS

Question 2: The DOE has been investigating retrofit solar heating and cooling technologies for some time. What types of technologies are proving to be economical?

Answer: Active solar domestic hot water systems are being retrofitted economically throughout the U.S.; in many regions of the U.S., retrofit active solar space heating systems are also economical. For residential buildings, passive solar sunspaces are an economical and effective heating retrofit solution for single-family and townhouse buildings having appropriate orientations, space, and interior layouts. Roof apertures represent the first of the daylighting systems to show nearer term commercial possibilities. These systems are currently the most promising retrofit cooling strategy for nonresidential buildings. They can be installed at moderate incremental cost and will show an attractive return on investment. These daylighting systems offer a triple payoff by (1) supplying quality lighting, (2) reducing electrical usage for artificial lighting, and (3) reducing the attendant cooling loads produced by artificial lights. Moreover, these systems contribute little unwanted thermal gain or loss to the buildings.

QUESTIONS FROM SENATOR DOMENICI
ELECTRIC ENERGY SYSTEMS AND STORAGE

QUESTION 1: The Electric Energy Systems budget was cut in half--from $20.6 million in FY 85 down to only $10 million in FY 86. Important activities have been slashed or zeroed, including Electromagnetic Pulse Impact Analysis (work considered vital to national security needs), failure mechanisms, High Voltage D.C. research, research on new dielectric and magnetic materials, superconducting/ambient technologies and battery energy storage testing. What is the rationale for these drastic cuts? With increased prospects for wheeling of power between various regions of the country, shouldn't we be doing more in these research areas? Is EPRI planning to absorb some of this research, and if so, how much of it? How can we be assured that any activities being undertaken by EPRI will see a smooth transition from DOE to EPRI?

ANSWER 1: EES sponsors mid-to-long term research aimed toward developing technologies for use in future electric networks. The research design incorporates mechanisms that facilitate the transfer of results to the private sector for additional development toward commercialization. As with all research plans, priorities must be established to ensure that a portfolio evolves that is consistent with budgetary considerations and programmatic guidelines. In the context of the present Presidential budget, primary focus will shift toward the transfer of the knowledge base generated from this multi-faceted research program to the private sector. This is particularly true in the Systems Technology research area where many of the projects are moving towards logical conclusions and transfer to the private sector. The HVDC and new materials program (contractual obligations require close-out costs to be incurred in the new materials project) will move toward a well defined technology transfer activity. For example, the superconducting cable research has resulted in the completion of a full series of normal and transient voltage tests. Evaluation of a directly related spin-off for an ambient cable insulated with biaxially oriented synthetic tapes continues. This has resulted in the private sector undertaking an extensive four year testing program. DOE will have to withdraw from its agreement with EPRI to co-fund the BEST facility. It is assumed that EPRI and PSE&G the facility operator, will continue to support the project. Given that only $3 million of the $11.8 million appropriated has been spent on the Hawaii Deep Water Cable, there are sufficient funds remaining to continue and complete laboratory design verification (a major program milestone). In the Reliability R&D area, the EMP impact analysis will continue its vitally important research, while the failure mechanisms program will draw to a close and transfer the information to the private sector. The control of large interconnected systems is an area that has been under investigation for a long time. Research into this issue will be diminished with industry expected to assume a larger role. Research will be continuing on a smaller scale to develop methods and techniques to operate the electrical networks more efficiently in both emergency and normal conditions. Further, the results of research specifically focusing on this concern will be fully documented and a program planned to transfer the data to the private sector. EPRI has shown considerable interest in the New Materials, failure mechanism, and the HVDC research programs. It is assumed that this interest will result in funded research programs. DOE and EPRI maintain a continuous dialogue to ensure that both programs function in the most cost-effective manner and the needs of the nation and the utility industry are satisfied. Several programs have been co-funded or transferred between the two organizations. The established networks should assure that any transfer of programs will be smooth and effective.

QUESTIONS FROM SENATOR DOMENICI

Photovoltaics

Question 1:	Where are the major cuts being taken in photovoltaics to account for the $12 million reduction in this budget compared to 1985?
Answer:	The $12 million reduction consists of two parts. The larger part is $9.5 million that was appropriated in FY 1985 for the SMUD (Sacramento Municipal Utility District) project which is not being requested in FY 1986. The remaining reduction is in the Systems Research Activities, specifically in the residential experimental station support and in some slight reduction in data collection from several mid-size field experiments. There are no changes either in emphasis or direction of the PV program.

QUESTIONS FROM SENATOR DOMENICI

Photovoltaics

Question 2: What is the best way to foster successful commercialization of photovoltaic technology? What are the pros and cons of continued energy tax credits in this area?

Answer: The best method to foster successful photovoltaic commercialization in the short term is to continue the intense technology transfer efforts that have facilitated, without Government capital funding (a) a 100 kilowatt (kw) system in Puerto Rico, (b) a 190 kw residential system at John Long Homes in Phoenix, Arizona, (c) a planned 300 kw system in Austin, Texas, (d) a planned 100 kw system in Boston, Massachusetts, and (e) a 50 kw residential system in San Diego, California. Other technology transfer efforts have resulted in the production of an international awareness publication to inform potential foreign buyers of the capabilities of the U.S. photovoltaic industry and a combined federal effort to spur the export of U.S. made photovoltaic products. Successful photovoltaic commercialization in the long term is dependent on the results of the on-going research and development efforts to produce the technology which will allow industry to produce high efficiency, low cost photovoltaic products. Substantial reduction in module costs, to reach a $1.00 per watt goal, will be necessary to allow PV technology to successfully compete with other energy sources.

Solar tax credits have played a major role in the substantial increase in domestic sales and capacity that the U.S. PV industry has experienced over the past several years. Besides serving as a means to equalize the tax treatment for renewable technologies, in comparison to fossil fuels, the solar tax credits (a) increase nearer term industrial commitments in that the potential time to cost competitiveness is reduced, and (b) provide a means for the private sector to design, construct, and gain experience with PV system.

The solar tax credits, like any other tax credit program, result in a loss of revenue to the U.S. Treasury. They also may focus interest on less than optimal PV systems and have the potential to cause a distortion in the market place. In theory, they could tend to slow industrial development of technology capable of broad competitiveness in unsubsidized markets. It should be noted that PV has reached the point where unsubsidized competitiveness has been established in several remote or specialty types of applications representing important initial market entry points.

QUESTIONS FROM SENATOR DOMENICI

SOLAR THERMAL ENERGY SYSTEMS

Question 1: What are the construction materials requirements of a solar thermal plant in comparison to an equivalent-sized coal or nuclear plant?

Answer: Based on prototype designs of Solar Thermal plants, it would appear that the construction materials for foundations, pumps and piping, heat exchangers, steam generators, turbine/generators, condensers and cooling towers, switch gear and other supporting facilities requirements would be comparable for an equivalent-sized coal or nuclear plant. A solar plant would require large quantities of concentrator materials, such as mirrors, mirror module structures and drives and pedestals which would not be required for a fossil or nuclear plant. However, a solar plant does not require any fossil or nuclear fuel handling equipment or large environmental or safety equipment that fossil and nuclear plants require.

QUESTIONS FROM SENATOR DOMENICI

SOLAR THERMAL ENERGY SYSTEMS

Question 2: How do today's costs of solar thermal power (dollars per installed kilowatt and mills per kilowatt-hour) compare to conventional power sources (coal and nuclear)?

Answer: The Luz plant at Daggett, CA, and the La Jet plant at Warner Springs, CA, represent the state of the art in solar thermal electric generation plants. It has been reported that the installed cost, at least for the La Jet facility, was less than $4000/kW. At this level solar thermal compares favorably with nuclear but is significantly higher than coal. We are unaware of the exact selling cost of the power (mills per kilowatt-hour) but apparently it was sufficient under the California situation to provide an adequate return on investment for the investors.

QUESTIONS FROM SENATOR DOMENICI

GEOTHERMAL RESEARCH

Question 1: The geopressured resource budget has been cut from $5.4 million to $3.6 million. Is this program adequately funded to carry through with DOE's responsibilities in conjunction with the cooperative work being conducted with EPRI in Louisiana and Texas? What is the percentage of support provided by EPRI in this program?

Answer: The $3.6 million appropriation in FY86 will be adequate to conduct planned activities at the Pleasant Bayou well site, where the cooperative experiment with EPRI will take place. In this experiment, the heat energy content of brine produced from subsurface geopressured reservoirs will be used to generate electric power. Natural gas, carried to the surface with the brine, also may be used to generate electricity. The agreement between DOE and EPRI assigns certain tasks to each participant; no money will change hands. We understand that the cost of EPRI's participation will be about $500,000. The DOE costs attributable to cooperative participation in this project will be about $1 million.

QUESTIONS FROM SENATOR DOMENICI

GEOTHERMAL RESEARCH

Question 2: Why is the geothermal technology transfer funding zeroed in FY 86? Hasn't this program been a cost-effective method to transfer technology to the ten key western states with the greatest geothermal potential? How else can this transfer of research be accomplished, if not with a dedicated technology program? Isn't technology transfer the whole rationale for DOE's research in geothermal--as well as other--conservation and renewable research areas?

Answer: The Department believes that to fully realize timely benefits of Federal R&D investments, technology transfer provides an indispensible link for fostering eventual new technology adaption and future advancement by the private sector. Accordingly, technology transfer continues to play an important role in the DOE geothermal research program. Recent solar technology transfer budget growth has resulted in the development of program efficiencies and a prior year balance for planned FY 1986 activities. These factors will allow for a reduced FY 1986 budget request. In addition to the solar technology transfer budget line item, individual renewable energy technologies, such as goethermal, also integrate funding for communicating results to industry and the research community into their programs.

Federal funding of state geothermal development activities is no longer required since this program has accomplished its objectives. Resources have been inventoried, and the ten Western states now have a sufficient data base and expertise to permit normal market forces to determine the appropriate development of commercially viable geothermal projects using available technology.

APPENDIX VIII

ADDITIONAL MATERIAL SUBMITTED FOR THE RECORD

PETROLEUM MARKETERS ASSOCIATION OF AMERICA
Representing Independent Petroleum Marketers

STATEMENT OF THE PETROLEUM MARKETERS ASSOCIATION OF AMERICA
ON THE DOE FY86 BUDGET
FOR OIL HEAT RESEARCH
BEFORE THE
SENATE ENERGY AND NATURAL RESOURCES COMMITTEE'S
SUBCOMMITTEE ON ENERGY RESEARCH & DEVELOPMENT

May 14, 1985
Washington, D.C.

Submitted By:

The Petroleum Marketers Association of America
1120 Vermont Avenue, N.W., Suite 1130
Washington, D.C. 20005

(202) 331-1198

Preface

The Petroleum Marketers Association of America is a federation of 41 state and regional trade associations representing 12,000 independent small business petroleum marketers. Members include retail fuel oil dealers, gasoline and diesel fuel wholesalers, commissioned distributors of gasoline and gasoline reseller-retailers. Members also wholesale or retail many other petroleum products including kerosene, LP gas, aviation fuels and motor oils, as well as residual fuel oil. Together our marketer members in 1984 sold approximately 75 percent of the No. 2 Heating Fuel, 50 percent of the gasoline and 59 percent of the diesel fuel sold in America under either their own private brand or the trademark of their supplier. In addition PMAA marketer members employed over 239,00 persons.

Statement of PMAA Before The Energy Research & Development Subcommittee of The Senate Energy & Natural Resources Committee

The Petroleum Marketers Association of America (PMAA), formerly the National Oil Jobbers Council (NOJC), appreciates the opportunity to submit this statement supporting R & D activities for oil heat in DOE's FY86 Budget.

PMAA is a federation of the 41 state and regional associations (listed on Attachment I) representing some 12,000 independent marketers of a wide range of petroleum products including heating fuels and motor fuels. Heating oil distributors provide fuel, heating equipment and service to 12 million American homes.

Federal Role for Oil Heat R & D

Considering DOE's unique overview and responsibility for all forms of energy, it is appropriate that DOE develop a coordinated, cooperative oil heat industry equipment research and development program. Federal research funds that lead to greater conservation and lower energy costs can provide major benefits to the nation's consumers and especially to the poor. Federally funded research on combustion technologies at Brookhaven National Laboratory is estimated to save energy consumers $1.5 billion by the year 2000. That research, conducted from 1978 to 1984, cost $5.3 million.

The federal government should continue funding this successful program,, because there is no effective means to provide private support. Local oil heat marketers have no exclusive sales territories and no governmental approval for means to assess research and development surcharges to their customers. Major oil companies, which produce and refine oil products, no longer accept responsibility for any research and development activities on behalf of the equipment manufacturers or end users, whether it is automobiles, airplanes, or space heating.

Most manufacturers of oil heat equipment also make gas and/or electric appliances. With a relatively smaller sales potential in oil, it is understandable that the equipment manufacturers committed their limited resources where the government and the utilities are focusing their research dollars.

Proposed Conservation Programs

PMAA believes that research and development programs should be conducted by DOE to improve conservation with respect to oil heat. DOE programs can improve oil heating technology that is vital to our industry and to the 12 million American homes heated with oil.

PMAA proposes a dual approach so that DOE should conduct not only R & D projects to improve technology, but also technology transfer programs to put the R & D results to use.

Among the R & D projects, DOE should focus on two areas of conservation:

1. Increase the efficiencies of heating equipment:

    - o controls and retrofits to improve existing systems
    - o improve heat exchangers
    - o oil burners using new combustion processes
    - o high efficiency domestic water heaters
    - o heat pumps using fuel oil.

2. Evaluate Heat Equipment/Building Interactions to improve overall operating performance:

    - o for various structures, develop optimum equipment design, location and control characteristics

    - o improve distribution system designs and

    - o direct venting - improve heating systems to allow direct, through-the-wall venting that would eliminate the need for chimneys in new housing construction.

Proposed Funding Level

The Administration's FY86 Budget for DOE's Office of Buildings and Community Systems includes a program identified as Technology and Consumer Products. Within that program is a key activity labeled "Combustion-Heating Equipment", which includes combustion research on oil, gas and solid fuels. PMAA strongly supports this key activity, which is budgeted at $700,000.

PMAA expects that the DOE conservation programs for oil heat proposed above could easily achieve the same increase in efficiency as previous DOE programs conducted at Brookhaven National Labs. This could mean a savings on the order of a billion dollars to oil-heat taxpayers by the year 2000.

To accomplish this goal, the oil heat funding would be quite modest compared to the massive federal support for R & D for electricity and natural gas. While the potential savings to the American consumer easily justifies a research budget in excess of $15 million, the funding level for 1986 could be initiated at 15% of that amount to allow a phased build up of research activity to ensure that the money is spent wisely. Accordingly, PMAA asks that $2.25 million be authorized by DOE to conduct oil heating R & D including technology transfer.

Conclusion

Almost 20 percent of the homes in the U.S. heat with oil, and there are no research funds in the budget dedicated to oil heat. The $700,000 budget item for combustion research may be used for gas or solid research instead of oil at DOE's discretion.

PMAA supports efforts by the Senate to reduce the budget deficit. However, PMAA's proposed $2.25 million dedicated to research on oil heat is a small percentage of funds committed to gas and electric research, and an even smaller percentage of DOE budget of $2,456 million on non-defense energy R & D.

As a matter of equity, PMAA strongly urges the Committee to authorize the proposed $2.25 million dedicated to oil heat R & D. Thank you for your consideration of PMAA's position.

ATTACHMENT ONE

MEMBERS OF THE PETROLEUM MARKETERS ASSOCIATION OF AMERICA

The Petroleum Marketers Association of America represents the independent petroleum marketers who are members of these state and regional trade associations:

Alabama Oilmen's Association
Arizona Petroleum Marketers Association
Arkansas Oil Marketers Association, Inc.
California Independent Oil Marketers Association
Colorado Petroleum Marketers Association
Independent Connecticut Petroleum Association
Florida Petroleum Marketers Association
Georgia Oilmen's Association
Idaho Oil Marketers Association
Illinois Petroleum Marketers Association
Indiana Oil Marketers Association, Inc.
Intermountain Oil Marketers Association
Petroleum Marketers of Iowa
Kansas Oil Marketers Association
Kentucky Petroleum Marketers Association
Louisiana Oil Marketers Association
Michigan Petroleum Association
Mid-Atlantic Petroleum Distributors Association, Inc.
Mississippi Petroleum Marketers Association
Missouri Oil Jobbers Association
Montana Chapter, Intermountain Oil Marketers Association
Nebraska Petroleum Marketers, Inc.
Independent Oilmen's Association of New England
Fuel Merchants Association of New Jersey
New Mexico Petroleum Marketers Association
Empire State Petroleum Association
North Carolina Petroleum Marketers Association
Northwest Petroleum Association
Ohio Petroleum Marketers Association
Oklahoma Oil Marketers Association
Oregon Petroleum Marketers Association
Pennsylvania Petroleum Association, Inc.
South Carolina Oil Jobbers Association
South Dakota Petroleum Marketers Association
Tennessee Oil Marketers Association
Texas Oil Marketers Association
Virginia Petroleum Jobbers Association
Washington Petroleum Marketers Association
West Virginia Petroleum Marketers Association
Oil Jobbers of Wisconsin, Inc.
Wyoming Petroleum Marketers Association

The Petroleum Marketers Association of America is located at 1120 Vermont Avenue, N.W., Suite 1130, Washington, D.C. 20005. Telephone (202) 331-1198.

RDA
LOGICON

WRITTEN TESTIMONY OF DR. STUART L. RIDGWAY BEFORE SENATE SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT – PETE V. DOMENICI, CHAIRMAN

I thank the Subcommittee for the opportunity to present my views on the need for research in Ocean Thermal Energy Conversion (OTEC), and point out the opportunity that has been created by the successful demonstration of the Mist Lift (OTEC) concept on ocean water at the Natural Energy Laboratory of Hawaii in September 1983.

A cost study reported at the Winter Annual Meeting of the ASME in December 1984 showed that the capital cost of a Mist Lift OTEC power plant of 4 megawatts capacity would be $2,500/kilowatt, or less. Larger plants would cost less per kilowatt. These costs for a plant that uses "free fuel" are very low.

To complete the research and development of the Mist Lift OTEC process, the Congress should appropriate $500,000 in fiscal 1986, and $2,000,000 in fiscal 1987 for Mist Lift research and development. The Natural Energy Laboratory of Hawaii is a proper place to conduct that research. The reward for such expenditures will be a proven design of an OTEC electric power plant that will cost less than $2,500 per kilowatt of capacity. The low cost of such a plant will make its economic advantages obvious. Those private and public agencies charged with the responsibility to provide electric power to those areas that are endowed with the OTEC resource will step forward to build OTEC power plants that serve their customers. The development of a successful alternative to expensive imported oil will be of great consequence to our island possessions, isolated Navy bases, and many nations of our "backyard," the Caribbean and Central America.

May 14, 1985

Statement
On Behalf of the
Energy Committee
of the
Institute Of Electrical and Electronics Engineers
on
Electric Energy Systems & Energy Storage Systems
Before the
Senate Energy and Natural Resources Committee
Subcommittee on Energy Research and Development

May 10, 1985

The IEEE is the world's largest technical professional society with over 260,000 members worldwide, more than 215,000 of whom live and work in the United States. Its Energy Committee provides a forum for the development and public pronouncement of positions on energy issues of concern to the Institute. We would like to share with you our views on the Electric Energy Systems and Energy Storage Programs of the Department of Energy as proposed for Fiscal Year 1986. Specifically, we urge you to appropriate the full amount authorized for each of these program areas.

The IEEE has an official Institute position paper on "The Role of Electricity in the U.S. Economy" which has emphasized the fundamental importance of energy availability to the welfare and economic health of society. This position recommends an increased role for electricity in the nation's energy economy and calls for increased support of research and development programs to improve electric power systems' efficiency and reliability, as well as to provide advanced energy conversion technologies.

The IEEE has consistently supported the Electric Energy Systems and the Energy Storage Program in testimony before Congressional Committees having oversight over its budget. We strongly support continuation of these programs. A lasting commitment to research in such a complex and critical area is essential. Continuity of research is espoused by the majority but keeping both government and industry involved in a consistent way is not simple. We do not live in a time of instantaneous inventions and instantaneous rewards. Advancing technology requires hard, patient and deliberate efforts for an extended period. Further, to advance technology in this modern world requires significant investment in people and capital resources. It cannot be attacked with vigor in one year or one administration and abandoned totally in the following. Because of the importance of safety and reliability in electricity supply, many technologies must be demonstrated at or near commercial scale in order to be acceptable to the electric industry. Sharing the risk on these projects and providing funds for contruction of such facilities is a particularly difficult problem when budgets change dramatically from year to year.

We have reviewed the current program plan and are concerned that the lack of proposed funding may severely curtail ongoing research efforts from reaching a successful conclusion. Clearly the reduction in funding from $40.1 million to $26.1 million will have a detrimental impact on program administration, continuity and coordination.

The programs are designed with a knowledge of the energy requirements of the United States and the mandated rules of funding research given by the Department of Energy. The guidelines for what is appropriate for active government support are well articulated. The government involvement is principally focused on areas that are crucial to the economic well-being and security of the nation and which are high-risk and long-term research areas. These areas cannot or will not be attempted by non-government entities. Industry, principally through the Electric Power Research Institute (EPRI) is focused through its members to place emphasis on the solution of near-term problems. Manufacturers generally have not supported long-range high-risk research, which yields no immediate payback or profit. Most require a return on their research investments within five years or less. Tax structures, foreign government-supported competition, and the growing cost-price squeeze all tend to limit manufacturer research support. Any such research that does exist is directed toward improvement of existing lines of equipment in which they have a heavy investment. Internally supported research on new technologies, or on systems-related problems, is virtually nonexistent. Utilities' support of research is limited not only by their current financial strait, which is increasingly severe in some regions of the country, but also by regulation and local rate based pressures, and is generally limited to solution of their own immediate problems and the support of EPRI.

The idea of an appropriate government support of long-term, high-risk research is severely compromised by extreme shifts in funding levels. However, the current DOE administrators seem to have a sound understanding of the needs and of the funding required to meet the needs. We applaud this. We urge that this commitment to research in the electrical energy area be consistently followed in the future.

Studies in electric field effects for which the Congress provided increased funding in last year's budget, are facing reductions in FY 86. This is most unfortunate because public concern is ever growing over the health related effects of electric fields and a reduction in funding will certainly not permit any new research; it will result in the slowing down of current activity. This will come at a time when many state legislatures are considering some form of future standards "limiting" electric field effects on humans. Such standards conceived without adequate research and technical foundation, which the current DOE program is seeking to establish, would be most detrimental to the public benefit and business economy. Furthermore, the new work recently begun in magnetic fields and DC iom propagation will have to be substantially de-emphasized. It is the responsibility of the federal government to provide sufficient and unbiased information on the biological effects of electric fields.

Similarly the proposed FY 86 budget would severely reduce the investigation into the performance of power systems and equipment under the affect of electromagnetic pulses. These pulses could be generated by nuclear blasts at high altitudes in which no physical ground damage may be visible, but could produce not only a wide disruption of electric system continuity with resultant economic and public chaos but also a serious threat to national security. There is insufficient knowledge on these wave forms and their behavior on systems and equipment. Insufficient funding is being provided to carry on any new effort and precludes any testing from being made of equipment under these very adverse transient conditions. The testing process is obviously a very necessary part of the research, but it is a costly thing to do.

Another example of losing the use of an expensive research tool is the Battery Energy Storage Test (BEST) facility. This facility enables testing of new advanced battery types under realistic conditions. The BEST project has not been budgeted for any operating funds in FY 86 and yet the need for developing and testing new advanced battery types has not diminished. New battery types which are more efficient and cheaper are needed for electric utility load leveling and for electric vehicles of the future. Zinc-chloride batteries have just gone through extensive testing procedures, and the even more promising sodium-sulphur battery has been scheduled to be tested. Currently the private sector is supplying 60% of these operating funds and it is rather unlikely the private sector can assume a greater share of the operations without curtailing other necessary research activities.

Systems engineering R&D is needed to provide options for the future electrical network which will improve regional energy exchange and enhance essential service continuity during regional and national emergencies. The systems technology area is hardest hit in the proposed FY 86 budget. This program includes high voltage DC research, new materials for use in power systems (from 20 years or more into the future) of magnetic, dielectric, or semi-conductor nature. Power semi-conductor technology is being surrendered to foreign competitors, and there is a real need to make a serious effort to regain U.S. technological leadership in this field. DOE had planned to initiate a multi-year program to help in regaining this lead, however, inadequate FY 86 funding will cause the efforts to be aborted.

In summary, one must not lose sight of the hard facts of research: from the inception of the research program to commercial viability, a project may take 10-15 years to complete. We must be working today for systems to be available for commercial use in the next decade. The Electric Energy Systems and the Energy Storage Programs are both concerned with crucial developments. It will require adequate lead times and continuity of funding through the whole R&D cycle to achieve their goals. Research activities that can provide benefits to public health, national security, and the economic viability of our electric utility manufacturing industry are deserving of serious considerations of additional funding in FY 86.

Thank you for this opportunity to provide you with our views. We would be pleased to submit answers for any additional questions you might have.

Hearings on FY 1986 Department of Energy Conservation Budget

Testimony Submitted to:

Energy Research and Development Subcommittee
Energy and Natural Resources Committee

By:

Vincent M. Halsall
Vice President of Engineering
Battery Division
Johnson Controls, Inc.

Submitted March 27, 1985

We believe there are some facts that must be understood by the members of this Subcommittee in consideration of authorizing FY 1986 funds for the Department of Energy Conservation budget. Our comments specifically address funding needs of advanced lead-acid and zinc-bromine battery systems for electric vehicle applications.

As background, Johnson Controls through its Battery Division, is the largest U.S. manufacturer of automotive batteries. We have been a subcontractor to the Department of Energy (DOE) for battery development since 1976 and have also served as a subcontractor to several electric vehicle development programs.

WHY FEDERAL SUPPORT SHOULD GO TO OUR "BEST BETS" IN ELECTRIC VEHICLE BATTERY TECHNOLOGY - NOT JUST TO HIGH-RISK, UNPROVEN SYSTEMS.

-The U.S. goal should be to help develop electric vehicle technology so that it can be commercialized in the next five or ten years, not to spend another ten years looking for a so-called "perfect" battery system. The nation has already been disappointed by a series of technologies offering nothing but "promise." We know which systems can do the job, let's not let them flounder.

-Proponents of eliminating funding for battery systems promising near-term results assume that private industry will provide the capital needed to bring them to the point of commercialization. This is not true. Our development of advanced lead-acid and zinc-bromine batteries for electric vehicles will come to a virtual halt if funding by the DOE is discontinued. We are strong advocates of a future electric vehicle market and have made significant investments in battery development. But the near-term likelihood of a sizeable market is too remote for us - without Federal support - to expend the capital needed to complete development of these systems. A 1982 GAO report on electric vehicles supports our view:

> "It is unlikely that battery companies will perform extensive advanced battery R & D without Federal funding . . . The Federal Government's failure to continue to support advanced battery developmental efforts could, therefore jeopardize the future of EVs and risk forfeiting the $180 million Federal investment in EVs that has already been made."

-The U.S. Government must support U.S. industry in efforts to establish a technology that will reduce our reliance on foreign energy sources. While the 1970s are behind us, uncertainties of oil supplies are not. Electric vehicles can make a significant difference in avoiding the potential paralysis of our transportation system. The battery is the critical component in making this a reality.

FUNDING IS NEEDED FOR THE SYSTEMS WHICH WILL MAKE ELECTRIC VEHICLES A REALITY -- LEAD-ACID

-Lead-acid is the only system currently powering existing electric vehicles and will be the system needed to furnish reliable power for commercial electric fleets. It is the foremost system for which significant progress - of more than a 60% improvement in energy density - has been demonstrated under DOE research programs. Its improving performance is a moving baseline against which unproven, high-risk "advanced" systems must be measured. It is the only system for which additional performance gains (of 30% to 40%) can be confidently predicted.

-Development of of the lead-acid battery is not complete. While testing of our advanced cells by DOE supported laboratories has shown positive results, a significant amount of investment is required to meet established energy density goals.

. . . AND ZINC-BROMINE

-The zinc-bromine battery is the only one of the so-called "advanced" systems considered for electric vehicles that is cost-effective both in terms of initial and life cycle costs, whose technical feasibility can be demonstrated, and which can claim significant progress in the past year.

-Federal funding is needed to continue this effort. Without it, the results of over 100,000 man hours of privately-funded research will be shelved.

IN SUMMARY

We believe that continued support by the DOE of electric vehicle battery systems is imperative to further the accomplishments of the past several years. To drop support of our best candidates for a viable electric vehicle battery would mean that the multi-million dollar investments of U.S. taxpayers and industry will have been a fruitless exercise.

Funding for long-term research is acceptable. But we need to fund the sure winners to ensure that electric vehicles play a meaningful role in ameliorating our petroleum dependency. Private industries, such as Johnson Controls, will not go it alone.

Thank you for giving these views your sincere consideration.

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